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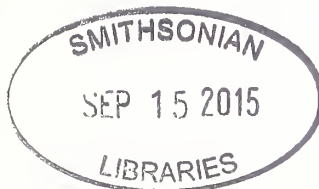
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Wingless *Paocryptorrhinus* (Coleoptera: Curculionidae) rediscovered in Tanzania: synonymy, four new species and a mtDNA phylogeography

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Abstract. The weevil genus *Paocryptorrhinus* Voss, 1965 is revised. The nominal taxon *Anchonidium hustachei* Hoffmann, 1965 is transferred to *Paocryptorrhinus* as *P. hustachei* (Hoffmann, 1965) comb. n. The nominal taxa *Anchonidium hustachei* Hoffmann, 1965 and *Paocryptorrhinus obsitus* Voss, 1965 are considered conspecific and the name *A. hustachei* Hoffmann, 1965 is a senior subjective synonym of *P. obsitus* Voss, 1965 syn. n. The genus, previously known for a single species from the wet forests on geologically young volcanic mountains in northeastern Tanzania, is reported from two other forest types: the old crystalline East Arc Mountains and the lowland forest. Four new species, all from Tanzania, are described: *P. atropos* sp. n. (North and South Pare), *P. clotho* sp. n. (West Usambara), *P. hanangensis* sp. n. (Mt. Hanang) and *P. lachesis* sp. n. (Kimboza forest). A single specimen of an unnamed species is reported from East Usambara. The mtDNA barcoding sequences are analysed phylogeographically. Even though the genus was not recovered as a monophyletic clade in two of the molecular phylogenetic analyses, it is nevertheless hypothesized as being monophyletic based on numerous similarities in adult morphology, biology and based on the geographical proximity of all records. The uncertain phylogenetic position of *Paocryptorrhinus* is briefly discussed and the genus is transferred from Brachycerinae: Erihriniini to Molytinae *incertae sedis*.

Key words. COI, DNA barcoding, Eastern Arc Mountains, East Africa

INTRODUCTION

Taxonomic literature contains numerous poorly known taxa that are mentioned only when described and that are then seemingly forgotten. A significant, if not the predominant number of genus- and, particularly, species-group Coleoptera taxa from “exotic” localities (i.e. far from the historical taxonomic centres of expertise located in Europe and elsewhere) can be classified as such. Once introduced, the names are repeatedly mentioned in catalogues, while their true identity, taxonomic diversity and distribution, monophyly and phylogenetic position, immature stages and habitat remain elusive. Such state of affairs might continue indefinitely, unless the taxon suddenly turns out to be of economic significance and gains importance and attention. This was the case with *Agrilus planipennis* Fairmaire, a jewel beetle from the Asian Pacific Region. This was a taxonomically neglected and poorly known species until it suddenly spread over most of eastern North America and became an invasive ash killer of cosmic proportions (Jendek & Grebennikov 2011). Such examples form the negligible minority within poorly known taxa, while the overwhelming majority continues to drag along their ghostly existence decade after decade. One such example among the weevils is the subject of the present paper.

The generic name *Paocryptorrhinus* was introduced a half century ago by Eduard Voss (1965) for his new species *P. obsitus* from the geologically young volcanic mountains in northeastern Tanzania. The holotype was sampled from “humus” (=leaf litter) in the forest on the eastern slopes of Mount Kilimanjaro at 2700 m, while 12 paratypes came either from the vicinities of Marangu village on the south-eastern slope of the same mountain, or from nearby Mount Meru, Mount Oldeani and the Ngorongoro highlands (Fig. 11). These localities correspond closely to the geologically young (<2 Ma) volcanic highlands of the so-called Ngorongoro-Kilimanjaro Volcanic Belt (NKVB, Nonnotte et al. 2008). The type series was collected by the Belgian entomologists Pierre Basilewsky and Narcisse Leleup of the Royal Museum for Central Africa in Tervuren during their epic 1957 journey to sample the East African biota. All weevils from their samples were given to Voss for study, who delivered the results in two parts published in 1962 and 1965, respectively. The latter contained the description of the new genus, accompanied by an adult habitus drawing in dorsal view and the head and prothorax in lateral view (Voss 1965: Fig. 7). Until present, this was the only time the genus has been mentioned in original literature (i.e. excluding catalogs).

This project was triggered by the necessity to identify *Paocryptorrhinus* specimen #3081 included as an outgroup representative in the phylogenetic analysis of new wingless species of *Notaris* Germar from southwest China (Grebennikov & Kolov, unpublished). Comparison of the specimen's morphology with that of the other seemingly congeneric and newly sampled specimens suggested existence of other species, aside from the type species. This was further supplemented by the differences in their mtDNA barcodes. Another unexpected discovery was that the type species had already been named and assigned to a different genus (Hoffmann 1965) about one month before the genus *Paocryptorrhinus* was formally established by Voss. These discoveries necessitated the completion of the present paper, which had the following main goals: (1) to document the course of the work highlighted above; (2) to revise the genus taxonomically; and (3) to propose a phylogeographic scenario for the low-dispersing *Paocryptorrhinus* species biologically linked to highly isolated Afrotropical wet forests of contrasting origin and age.

MATERIAL AND METHODS

This study is based on examination of 18 adults of *Paocryptorrhinus* sampled from Tanzania and assigned to six species (*P. hustashei*, four formally named as new, and one consciously left unnamed as *Paocryptorrhinus* sp. #3081). Sixteen specimens were successfully sequenced for the Cytochrome Oxidase subunit 1 (5-prime end, i.e. the Barcoding fragment). Parts of the historical type series pertaining to two synonymous names of the type species were examined. Fifteen other specimens representing various species of mainly Molytinae and Brachycerinae were added to the DNA-based phylogenetic analysis as an extended outgroup. All 31 specimens used for DNA extraction have at least one unique identifier label pinned underneath with the code CNCCOLVG0000XXXX (shortened to #XXXX when specimens are cited in the text below). Some specimens with more than one unique identifier (for example a specimen with labels #5231, #7270, #7271) required repeated sequencing attempts. GenBank accession numbers for 16 *Paocryptorrhinus* sequences are given in the species descriptions; those of the 15 outgroup representatives are: HM417724, HQ986868, HQ987003, HQ987029, KJ445698, KJ445708, KJ672224, KJ672228, KJ672239, KJ672247, KJ672251, KJ672255, KJ672276, KJ841714 and KJ841726. A list of all species, specimen images, georeferences, primers, sequences, original chromatograms and other relevant data for all 31 sequenced specimens can be found online in the publicly accessible dataset "*Paocryptorrhinus*" on the Barcode of Life Data-base portal (doi: [dx.doi.org/10.5883/DS-PAOCRYPT](https://doi.org/10.5883/DS-PAOCRYPT)).

All methods used in the present work are the same as those explained in detail for a similarly structured work on the genus *Niphadomimus* (Grebennikov 2015). This includes specimen collecting and dissection, diagnostic species descriptions, process of DNA extraction, as well as the logic, software and implementation of phylogenetic analyses using Maximum Likelihood (ML) and Bayesian analysis as implemented in MEGA6 (Tamura et al. 2013) and BEAST v1.8.0 (Drummond et al. 2012), respectively. The matrix used for both analyses had a length of 658 base pairs (bp) and contained 31 sequences. The resulting topologies were visualized in FigTree v1.4 (Rambaut 2014). The ML tree was rooted with both representatives of Anthribidae (Choraginae genus *Styphlochoragus* Frieser and Anthribinae genus *Disphaerona* Jordan). The BEAST analysis was performed without rooting and without enforcing monophyly of any group. In the absence of relevant fossil data, time calibration was made by assuming strict linear molecular clock and the rate of 0.018% of nucleotide substitution per million years (Papadopolou et al. 2010). Tracer 1.6 (Rambaut et al., 2014) was used to graphically determine stationarity and to check convergence of runs.

Labels of holotypes (HT) and paratypes (PT) of the newly described species are cited in quotation marks. Letters [p] and [h] in square brackets denote printed and handwritten text on historical labels, respectively, while back slash \ separates text on individual labels. Weevil taxonomy follows Alonso-Zarazaga & Lyal (1999), with subsequent modifications by Oberprieler (2014) and Lyal (2014). Distribution maps are generated using the on-line SimpleMappr tool (Shorthouse 2010). The chronostratigraphic timing is that of Cohen et al. (2013). Terminology for male genitalia follows Wanat (2007). The length of the body was measured in dorsal aspect from the elytral apex to the anterior edge of the pronotum (standard length).

The following abbreviations were used to indicate the Museum depositories (followed by the name of the curator):

- BSUM Department of Biological Sciences, the University of Memphis, Memphis, USA (D. McKenna);
- CNC Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Canada (P. Bouchard);
- MRAC Musée Royal de l'Afrique Centrale, Tervuren, Belgium (M. De Meyer);
- NMW Naturhistorisches Museum, Wien, Austria (H. Schillhammer).

TAXONOMY

Paocryptorrhinus Voss, 1965

Type species. *Paocryptorrhinus obsitus* Voss, 1965: 361 fixed by original designation.

Diagnosis. Adult beetles of the genus *Paocryptorrhinus* are rather distinctive in their appearance and can be recognised relatively easily. The presence of postcoxal flanges on the prosternum (Figs 7I, J; Figs 9A–G) forming lateral walls along the canal for accommodating the rostrum in repose immediately separates *Paocryptorrhinus* from the majority of weevils not only in East Africa but also worldwide (except Molytinae: Aedemonini, a few Sophrorhinini and a few other stray genera). From the latter, *Paocryptorrhinus* can be recognized by having any two of the following three characters: (A.) eyes much reduced in size and seemingly consisting of a single, relatively large ommatidium (Fig. 9I) subequal in diameter to that of any funicular antennomere; (B.) the dorsal outline of the frons-to-rostrum junction in lateral view not forming an even curve, but marked by a depression (Fig. 3C), and (C.) elytra flattened, nearly parallel-sided most of their length (Figs 1A, C), and not shorter than 1.55 times their maximum width. Adults of two other weevil genera (*Ocladius* Schoenherr and *Isorhamphus* Faust) with a rostral canal were sifted together with *Paocryptorrhinus*. Those, however, have eyes with several ommatidia and vaulted elytra which are either rounded (*Ocladius*) or posteriorly tapered (*Isorhamphus*) in dorsal view.

Description. Integument uniformly dark-brown, often covered by waxy, white-brown coating obscuring colour and surface texture; standard length 2.31–3.96 mm; body notably elongate. Head capsule almost completely retracted into prothorax and not visible from above when rostrum in repose or directed ventrally. Eyes located latero-ventrally, small, flat, seemingly consisting of single ommatidium not exceeding in diameter maximum diameter of scapus (Fig. 9I). Rostral attachment to head capsule abruptly constricted laterally (in dorsal view) to half rostral width (Fig. 9A) and gently depressed dorsally in lateral view (Fig. 9I). Rostrum in lateral view almost straight; in dorsal view almost parallel-sided and slightly and evenly constricted at middle. Antennal attachments in apical 30–40% of rostral length; funicle with seven antennomeres; compact club consisting of three antennomeres. Pronotum weakly to markedly constricted laterally in anterior quarter; widest at middle; prosternum with deep rostral canal delimited laterally by lamellae anterior and posterior to procoxae (Figs 9A–G). Pro- and mesofemora without ventral tooth; hind femur with or without. Tibiae mucronate (Fig. 9J). Elytra parallel-sided; elytron with 10 striae each marked by single line of setiferous punctures;

striae 7 and 8 short, not reaching base (Fig. 9J) or apex of elytra. Hind wings absent. Metaventricle forming ventrally extended posterior wall of rostral canal (Fig. 9H); metepisternum and metaventricle fused without trace of metepisternal suture (Figs 7I–J, 9J); sclerolepidia absent (Fig. 9J). Male tergite 7 (Fig. 2I) without deep notch at posterior margin; sternite 8 (Fig. 2K) entire, not separated into hemisternites. Aedeagus weakly sclerotized, dorsally membranous; endophallus with weak sclerotization (Figs 2E–G).

Biology and distribution. All known *Paocryptorrhinus* specimens were collected by sifting wet leaf litter on the floor of wet primary Afrotropical forests. Host plants and larvae of this genus are unknown, together with all other more specific biological characteristics of these cryptic and rarely encountered beetles. The known distribution of *Paocryptorrhinus* is relatively small and limited to 12 localities in northeastern Tanzania (Fig. 11) at altitudes between 288 and 2700 meters.

Key to species of *Paocryptorrhinus*

1. Elytral stria 1 or 2 subequal in width to any of striae 4, 5 or 6 (Figs 1A, C; 6A, C); prosternum with postcoxal flanges smaller, postcoxal section of rostral canal half as deep as anterior section (Fig. 9A, B); pronotum with fine and numerous punctures (Figs 1A, C, 2A, C) 2
- Elytral stria 1 or 2 markedly narrower than any of striae 4, 5 or 6 (Fig. 3A); prosternum with postcoxal flanges greater, post- and antecoxal sections of rostral canal subequal in depth (Fig. 9C–G); pronotum with large and relatively few punctures (Figs 3A, C, 4A, C, 7A, C) 3
2. Smaller, body length 2.31–3.05 mm (Figs 1A–D; 2) *P. hustachei* comb. n.
- Greater, body length 3.75–3.92 mm (Fig. 6) *P. hanangensis* sp. n.
3. Ridges on interstriae 2, 4 and 6 markedly higher and longer than those on interstriae 1, 3, 5 (Figs 3, 4A–D); lateral outline of elytra in dorsal view formed by raised ridge on interstria 6 (Figs 3A, 4A) 4
- Ridges on interstriae 1 to 6 subequal in height and length (Fig. 5); lateral outline of elytra in dorsal view formed by raised ridge on interstria 5 (Figs 5A, 7A, 8A) 5
4. Elytral intervals 3 and 5 without raised ridges *P. atropos* sp. n. (North Pare)
- Elytral intervals 3 and 5 with raised ridges in posterior half *P. atropos* sp. n. (South Pare)

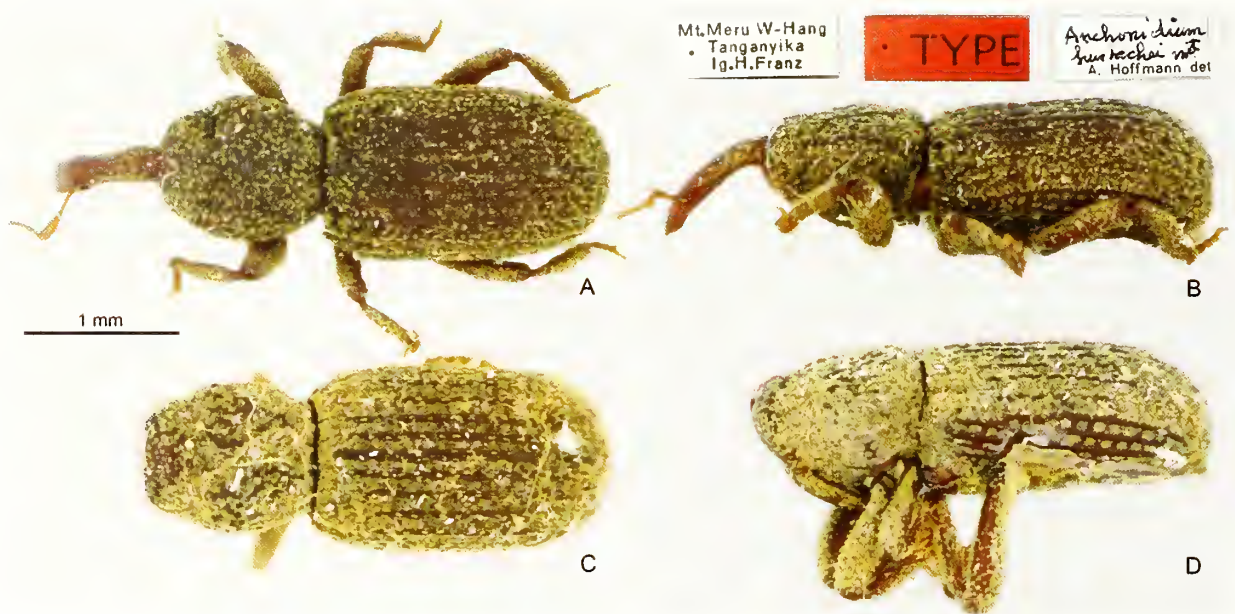


Fig. 1. *Paocryptorrhinus hustachei* comb. n., A–B: holotype of *hustachei*, unsexed, with three original labels; C–D: paratype of *obsitus*, unsexed.

- 5 Hind femur with large ventral tooth (Fig. 5C) *P. clotho* sp. n.
 – Hind femur without ventral tooth 6
- 6 Combined maximal width of elytral striae 4 and 5 subequal to that of striae 1 to 3 (Fig. 8A, C) *Paocryptorrhinus* sp. #3081
 – Combined maximal width of elytral striae 4 and 5 not more than 80% of that of striae 1 to 3 (Fig. 7A, C) *P. lachesis* sp. n.

***Paocryptorrhinus hustachei* (Hoffmann, 1965) comb. n.**
 Figs 1, 2, 9A, I, J

Anchondium hustachei Hoffmann, 1965: 397–398.

Type locality. Tanganyika, Mount Meru [Tanzania].

Type specimens. HT (Figs 1A–B) stated as male, not dissected (NMW): “Mt. Meru W-Hang Tanganyika Ig. H. Franz [p] \ TYPE [p] [red label] \ *Anchondium hustachei* m. [male sign] [h] A. Hoffmann det [p]”. 2 PT (NMW): not studied (see Remarks on the status of a specimen labelled as PT). Described from three specimens.

Paocryptorrhinus obsitus Voss, 1965: 361–362, Abb. 7, syn. n.

Type locality. Mt. Kilimanjaro, Versant Est, 2700 m, for. mont., humus [Tanzania].

Type specimens. HT (MRAC): not studied. 1 PT (MRAC) (Figs 1C–D): “PARATYPUS [p] [red label] \ étrépage sous Hagania [p] [blue label] \ I.R.S.A.C. - MUS. CONGO Kilimanjaro, Marangu 2400 m. 20–II–1956 J. et N. Leleup [p] \ R. DET. 7680 [p] A. [h]”; 1 PT (MRAC): “PARATYPUS [p] [red label] \ forêt mont., humus [p] [blue label] \ COLL. MUS. CONGO Tanganyika Terr. Mt. Meru, Olkokola, versant N.O. 2600 m. 8–VII–1957 [p] \ R. DET. 7680 [p] A. [h]”; 1 PT (MRAC): “PARATYPUS [p] [red label] \ étrépage sous forêt claire [p] [blue label] \ COLL. MUS. CONGO Tanganyika Terr. Mt. Meru, Olkokola, versant N.O. 2500 m. 8–VII–1957 [p] \ R. DET. 7680 [p] A. [h]”; all three paratypes have additional label: “Mission Zoolog. I.R.S.A.C. en Afrique orientale (P. Basilewsky et N. Leleup) [p]”. Described from 13 specimens.

Diagnosis. This species is recognized by the uniformly shaped six striae and interstria on the elytral disk in combination with its relatively small body length (not greater than 3.05 mm).

Description. Holotype, unsexed specimen (Figs 1A–B). Not sequenced for DNA barcode. Length: 2.94 mm. Smaller prosternal postcoxal flanges forming rostral canal twice shallower than that anterior of procoxae; raised elytral interstriae 1 to 6 reaching elytral base, subequal in height; lateral elytral outline in dorsal view formed by ridge on interstria 6; elytral striae 4 and 5 not markedly wider than others; hind femur without ventral tooth.

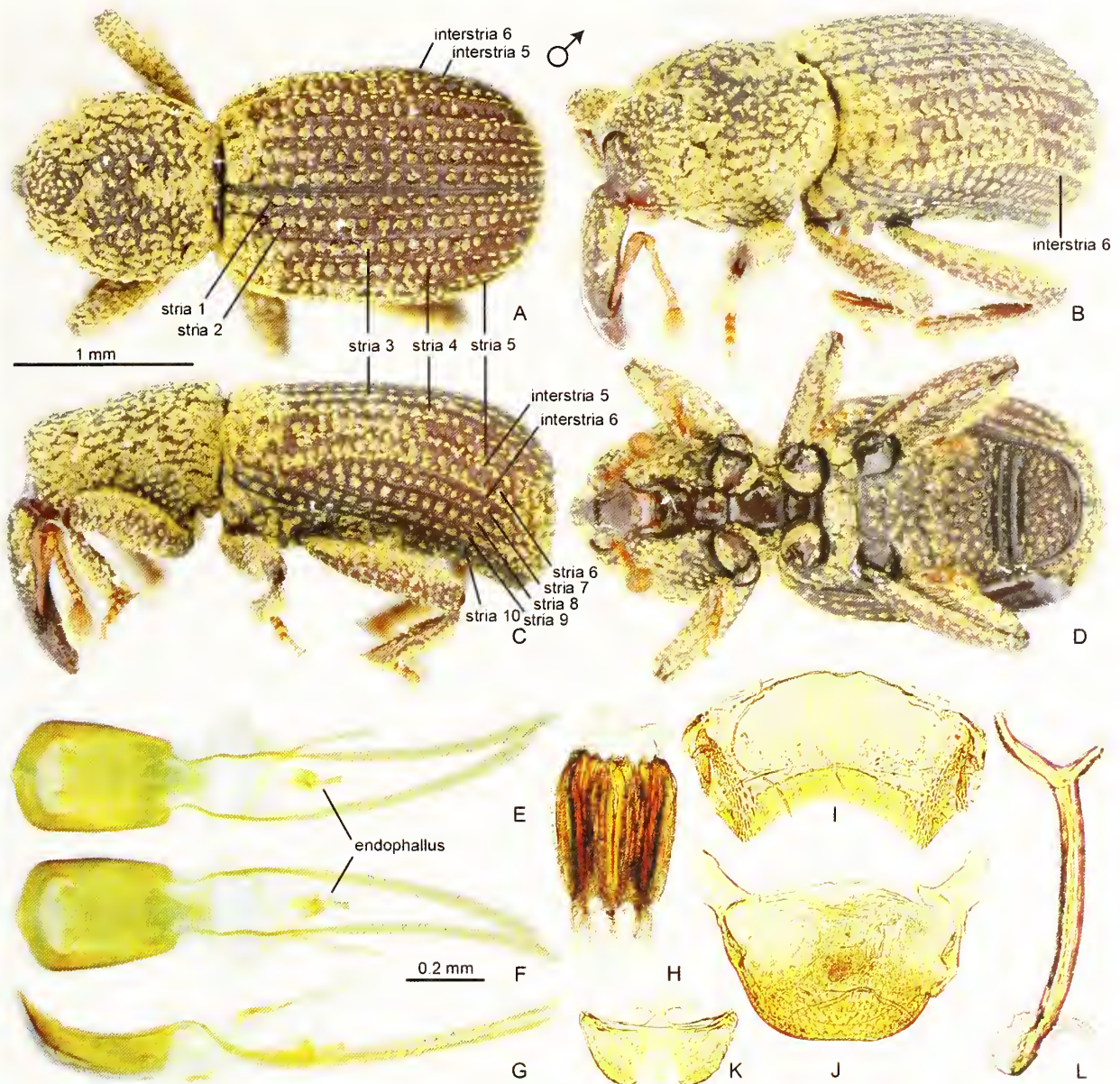


Fig. 2. *Paocryptorrhinus hustachei* comb. n., #4893 from Mt. Kilimanjaro, male. A–D: habitus; E–G: aedeagus & tegmen, dorsal (E), ventral (F) and lateral (G); H: proventriculus; I: tergite 7; J: tergite 8; K: sternite 8; L: sternite 9.

Intraspecific variation. GenBank accessions: KJ841713, KJ841717, KJ841719, KJ841722–KJ841724, KJ841728. Length: 2.31–3.05 mm.

Additional material examined. 12 exx in total. 5 exx (NMW): 1 ex, “Mt. Monduli Tanganyika lg. H. Franz [p] \ PARATYPE [p] [rad label] / Anchonidium hustachei m. [male sign] [h] A. Hoffmann det [p]”; 4 exx, “Gebirgswald oc. Marangu lg. H. Franz [p] \ Kilimanjaro Tanganyika [p]”. 7 exx (CNC): 1 ex, #4801 “TANZANIA, Mt. Kilimanjaro, Marangu route, S3.18424° E37.51344°, 2668 m,

25.xi.2012, sift01, V. Grebennikov”; 2 exx, #4844, #4845 “TANZANIA, Mt. Kilimanjaro, Marangu route, S3.21470° E37.51822°, 2198 m, 28.xi.2012, sift05, V. Grebennikov”; 1 ex, #4864, “TANZANIA, Mt. Kilimanjaro, Marangu route, S3.20141° E37.51903°, 2370m, 6.xii.2012, sift09, V. Grebennikov”; 2 exx, #4869, #4870 “TANZANIA, Mt. Kilimanjaro, Machame route, S3.14954° E37.24532°, 2124 m, 7.xii.2012, sift11, V. Grebennikov”; 1 ex, #4893 “TANZANIA, Mt. Kilimanjaro, Umbwe route, S3.16197° E37.28464°, 1993 m, 8.xii.2012, sift13, V. Grebennikov”.

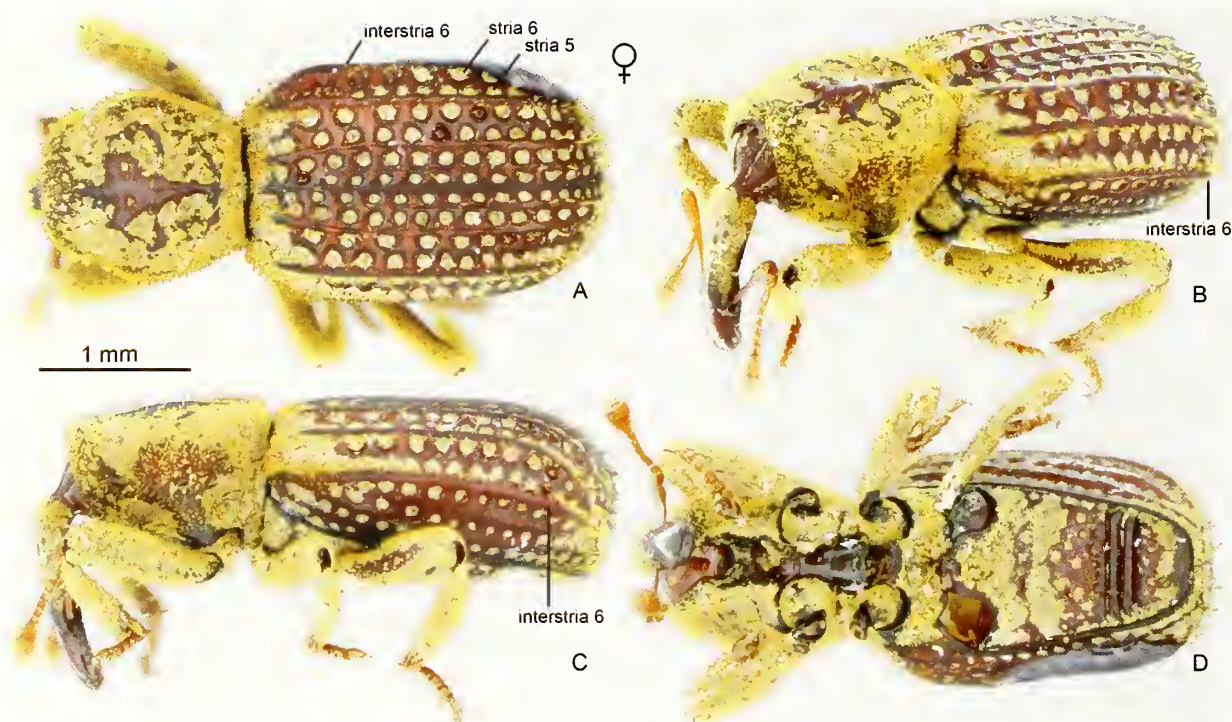


Fig. 3. *Paocryptorrhinus atropos* sp. n., #7271 from North Pare, female. A–D: habitus.

Distribution. This species is known from five isolated wet forests on volcanic mountains of the geologically young NKVB (Fig. 11) in northeastern Tanzania. Elevation: 1993–2700 m.

Remarks. The type specimens of both nominal historical names pertaining to *P. hustachei* are similar to each other (Fig. 1), while their type localities are about 60–70 km apart (Fig. 11). Each name was proposed by two authors, respectively, unaware of each other and published a month apart. These considerations suggest that both species names are subjective synonymous. Hoffmann's (1965) paper came out in the issue of the journal published on May 26, 1965 (endleaf), while the volume containing Voss (1965) paper was printed in June 1965 (verso of title page). Consequently, the name introduced by Hoffman is a senior subjective synonym of Voss' name.

Hoffmann (1965: 398) stated that he had studied three *hustachei* specimens: two males from Mount Meru (one of them designated by him as the "type" (=holotype, ICZN Article 73.1.1, Figs 1A–B) and a female from Machame, Mount Kilimanjaro. The series of this species received on loan from NMW contained six conspecific specimens all collected by Herbert Franz, two of them with red labels "TYPE" and "PARATYPE", respectively. The former specimen from Mount Meru is considered herein as the holotype (Figs 1A–B). The latter is labeled as originating from Mount Monduli (Fig. 11), which is a separate, thin-

ly forested and much smaller volcanic cone about 30 km West of Mount Meru, which itself is situated 60–70 km West of Mount Kilimanjaro (Fig. 11). The specimen with the paratype label does not agree geographically with any of the two paratypes mentioned in the original description and, therefore, its paratype status is refuted.

***Paocryptorrhinus atropos* sp. n.**

Figs 3, 4, 9C, D, H

Diagnosis. This species is recognized by the unique arrangement of elytral interstriae, of which 1, 3 and 5 are absent in at least the basal half of the elytra, while interstriae 2, 4 and 6 are markedly enlarged along their entire length.

Description. Holotype, male, (Fig. 5). GenBank accession: KJ841721. Length: 4.29 mm. Greater prosternal postcoxal flanges forming rostral canal subequal in depth to that anterior of procoxae; elytral interstriae 1, 3 and 5 without raised ridged entirely (Figs 3A–C, North Pare population) or in anterior half only (Figs 4A–C, South Pare population); raised ridges on interstriae 2, 4 and 6 markedly enlarged; lateral elytral outline in dorsal view formed by ridge on interstria 6; elytral striae 4 and 5 not markedly wider than others; hind femora without ventral tooth.

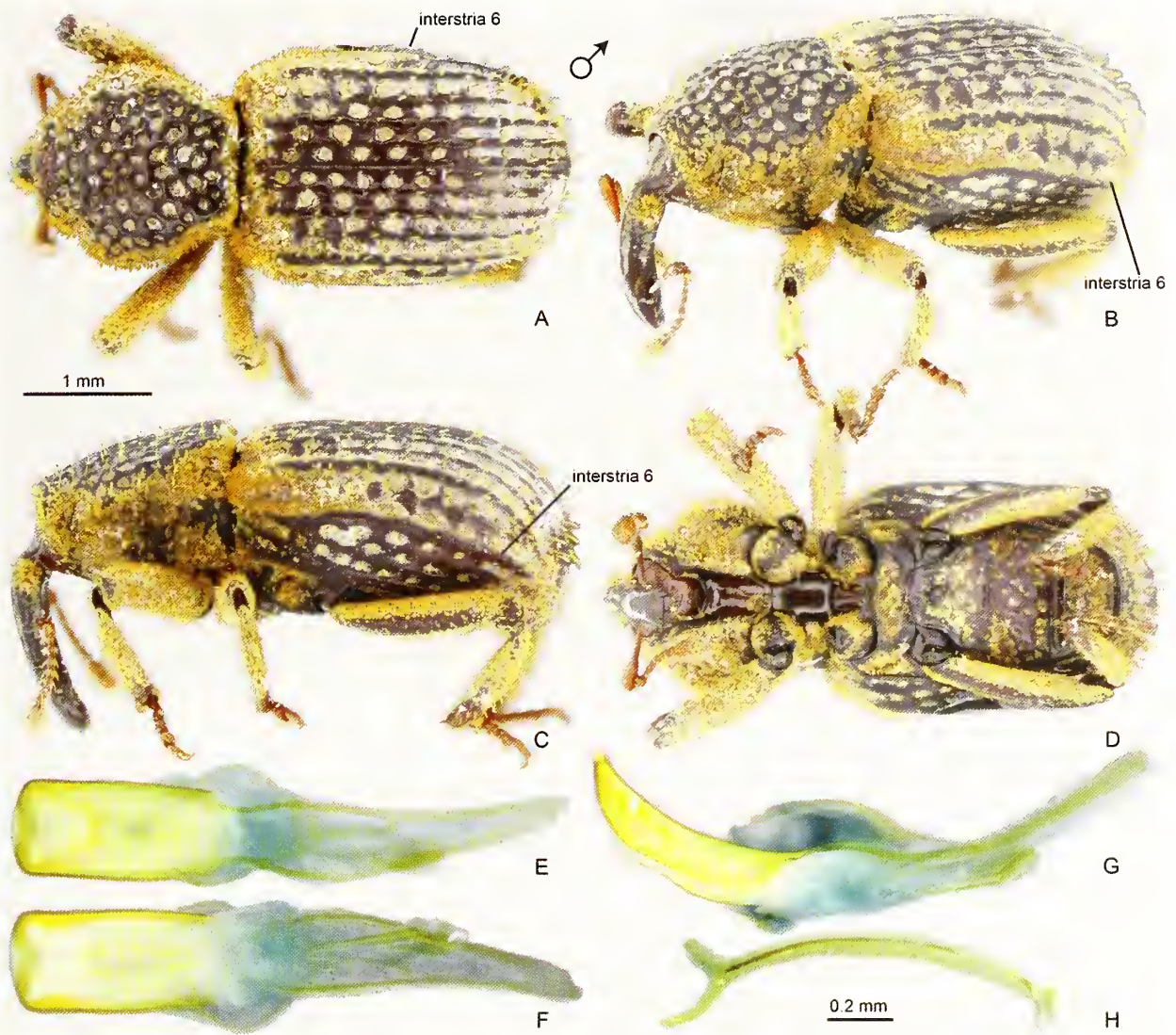


Fig. 4. *Paocryptorrhinus atropos* sp. n., holotype, #5438 from South Pare, male. A–D: habitus; E–G: aedeagus and tegmen, dorsal (E), ventral (F) and lateral (G); H: sternite 9.

Intraspecific variation. GenBank accession: KJ841718. Length: 3.73–4.34 mm.

Material examined. HT (Fig. 4) male (CNC): #5488 (= #5439), “TANZANIA, South Pare Mts., Chome For., S4.27145° E37.92347°, 2072m, 4.i.2013, sift40, V.Grebennikov”. PT (CNC, BSUM): 1 ex, #5436 (= #5467), same data as the holotype; 3 exx, #5231 (= #7270, = #7271), #5232 (= #7272, = #7273) and one not numbered, “TANZANIA, North Pare Mts., Kindoroko For., S3.74313° E37.65022°, 1987m, 23.xii.2012, sift25, V.Grebennikov”.

Distribution. This species is known from both South and North Pares in northeastern Tanzania. Elevation: 1987–2072 m.

Etymology. The species epithet is the Latinized Greek mythical name of Atropos, one of three Morai (= Fates), who cut the thread of life; noun in apposition.

Remarks. Three attempts to amplify DNA from each of two North Pare specimens failed (hence three unique identifiers on each specimen) and, therefore, they are not represented on the phylogenetic tree (Fig. 10).

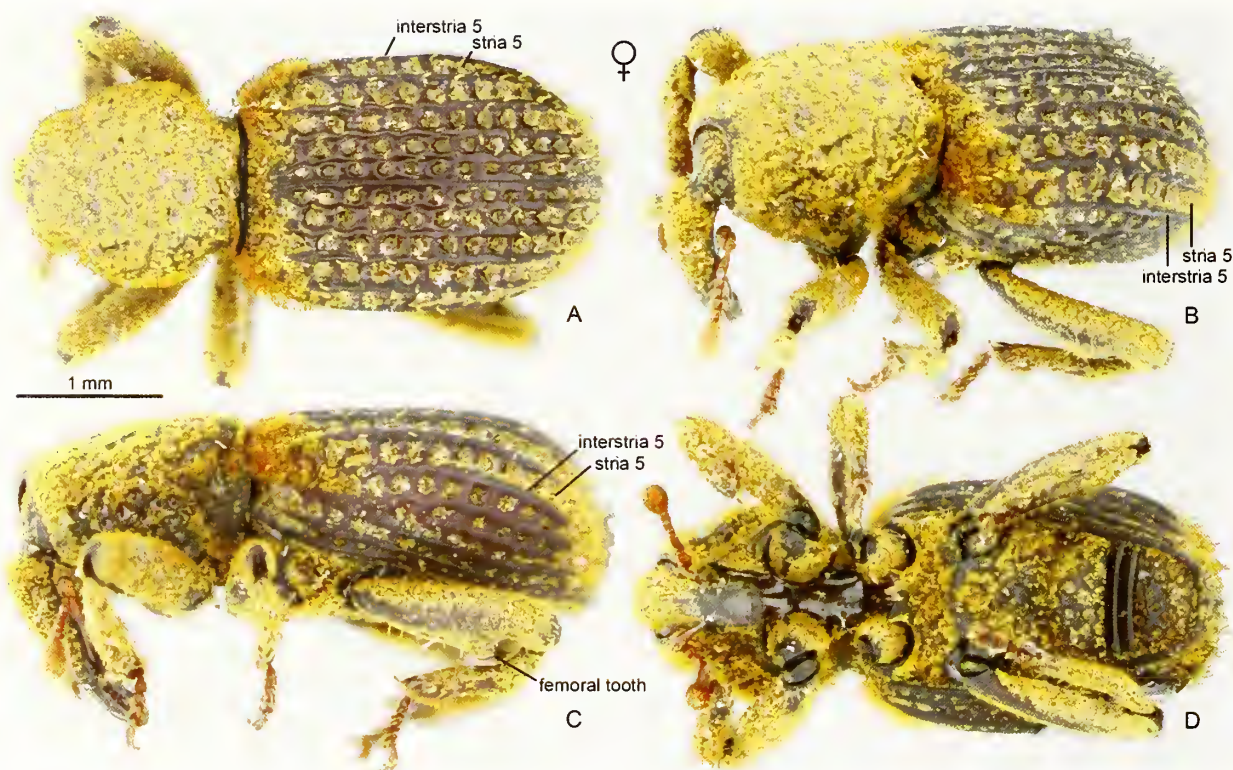


Fig. 5. *Paocryptorrhinus clotho* sp. n., holotype, #5476 from West Usambara, female. A–D: habitus.

Paocryptorrhinus clotho sp. n.

Figs 5, 9E

Diagnosis. This species is unique by having a markedly developed ventral tooth on each hind femur (Fig. 5C).

Description. Holotype, female (Figs 5, 9E). GenBank accession: KJ841727. Length: 4.13 mm. Greater prosternal postcoxal flanges forming rostral canal subequal in depth to that anterior of procoxae; raised elytral interstriae 1 to 6 reaching elytral base, subequal in height; lateral elytral outline in dorsal view formed by ridge on interstria 5; elytral striae 4 and 5 not markedly wider than others; hind femur with ventral tooth (Fig. 5C).

Intraspecific variation. GenBank accessions: KJ841712, KJ841716. Length: 3.68–4.13 mm.

Material examined. HT (Figs 5, 9E) female (CNC): #5476, “TANZANIA, W. Usambara Mts., Mazumbai For., S4.81054° E38.49858°, 1618m, 11.i.2013, sift43, V.Grebennikov”. PT (CNC): 1 ex, #5477, same data as the holotype; 1 female, #5478, “TANZANIA, W. Usambara Mts., Mazumbai For., S4.82634° E38.49690°, 1860m, 12.i.2013, sift46, V.Grebennikov”.

Distribution. This species is known only from the Mazumbai forest in West Usambara, northeastern Tanzania. Elevation: 1618–1680 m.

Etymology. The species epithet is the Latinized Greek mythical name of Clotho, one of three Morai (= Fates), who spun the thread of life; noun in apposition.

Paocryptorrhinus hanangensis sp. n.

Figs 6, 9B

Diagnosis. This species is recognized by the uniformly shaped six elytral discal striae and interstria, in combination with its relatively greater body length (not smaller than 3.75 mm).

Description. Holotype, female (Figs 6, 9B). GenBank accession: KJ841725. Length: 3.75 mm. Smaller prosternal postcoxal flanges forming rostral canal twice shallower than that anterior of procoxae; raised elytral interstriae 1 to 6 reaching elytral base, subequal in height; lateral elytral outline in dorsal view formed by ridge on interstria 6; elytral striae 4 and 5 not markedly wider than others; hind femur without ventral tooth.

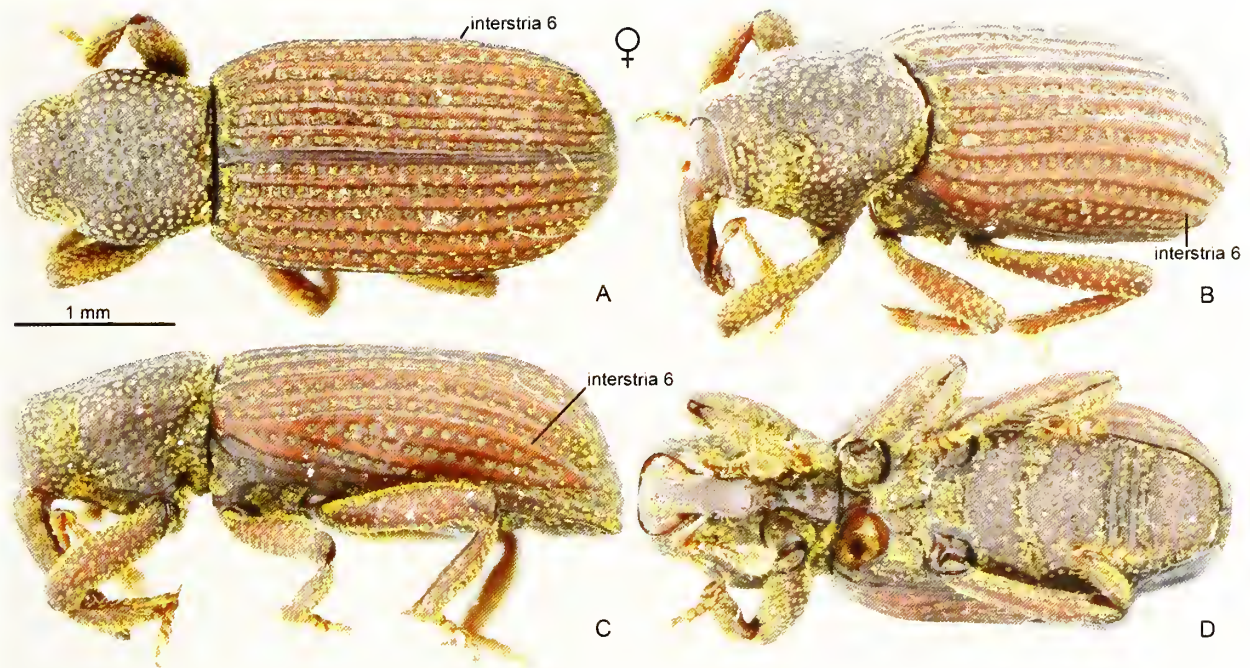


Fig. 6. *Paocryptorrhinus hanangensis* sp. n., holotype, #5086 from Mt. Hanang, female. A–D: habitus.

Intraspecific variation. GenBank accessions: KJ841720. Length: 3.75–3.92 mm.

Material examined. HT (Figs 6, 9B) female (CNC): #5086, “TANZANIA, Mt. Hanang, NE slope, S4.41621° E35.40281°, 2652m, 13.xii.2012, sift15, V.Grebennikov”. PT (CNC): 1 female, #5147 (= #5148) “TANZANIA, Mt. Hanang, NE slope, S4.43077° E35.41593°, 2283m, 15.xii.2012, sift20, V.Grebennikov”.

Distribution. This species is known only from Mount Hanang, northeastern Tanzania. Elevation: 2283–2652 m.

Etymology. The species epithet is an adjective derived from the name of its type locality, Mount Hanang in north-eastern Tanzania.

***Paocryptorrhinus lachesis* sp. n.**

Figs 7, 9F.

Diagnosis. This species is most easily recognized by the deep and abrupt lateral constriction of the pronotum in the anterior quarter (Fig. 7A).

Description. Holotype, male (Fig. 7, 9F). GenBank accession: KJ841715. Length: 3.96 mm. Greater prosternal postcoxal flanges forming rostral canal subequal in depth

to that anterior of procoxae; raised elytral interstriae 1 to 6 reaching elytral base, subequal in height; lateral elytral outline in dorsal view formed by ridge on interstria 5; elytral striae 4 and 5 not markedly wider than others; hind femur without ventral tooth.

Material examined. HT (Fig. 7) male (CNC): #3603, “TANZANIA, Kimboza forest, 7°01'20"S 37°48'13"E, 8.i.2012, 288m, sift.24, V.Grebennikov”.

Distribution. This species is known only from the holotype found in the Kimboza forest. Elevation: 288 m.

Etymology. The species epithet is the Latinized Greek mythical name of Lachesis, one of three Morai (=Fates), who measured the thread of life; noun in apposition.

Remarks. External morphological peculiarity of the single known male specimen (Figs 7, 9F), along with its distinct DNA sequence (though relatively short and consisting of only 407 nt) and a large geographical gap separating it from the rest of the genus (Fig. 11) triggered its recognition as a formally named species (unlike *Paocryptorrhinus* sp. #3081; see below).

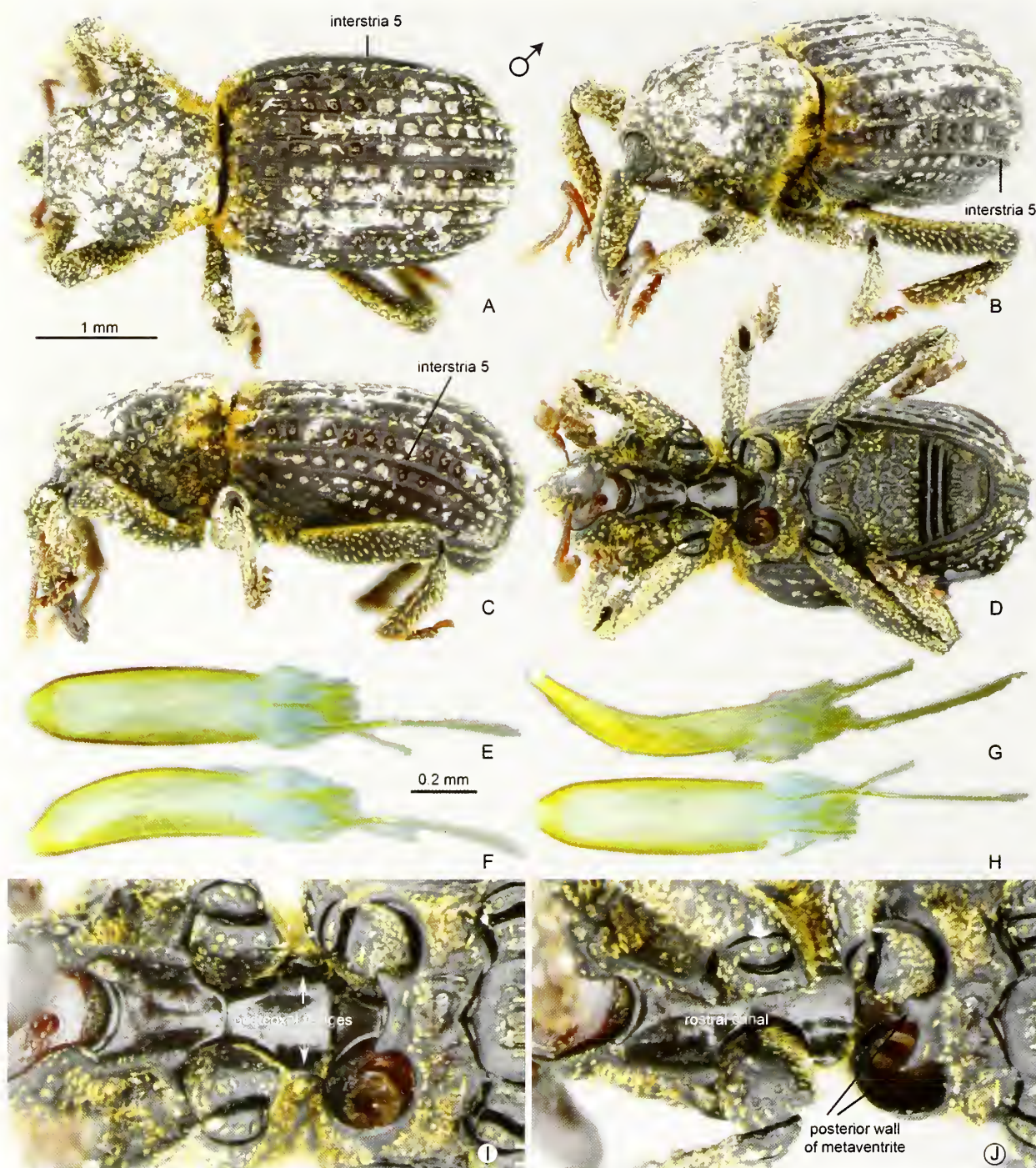


Fig. 7. *Paocryptorrhinus lachesis* sp. n., holotype, #3603 from Kimboza forest, male. A–D: habitus; E–H: aedeagus and tegmen, dorsal (E), ventro-lateral (F), lateral (G) and ventral (H); I–J: prosternum, meso- and metaventrums showing rostral canal, ventral (I) and latero-ventral (J).

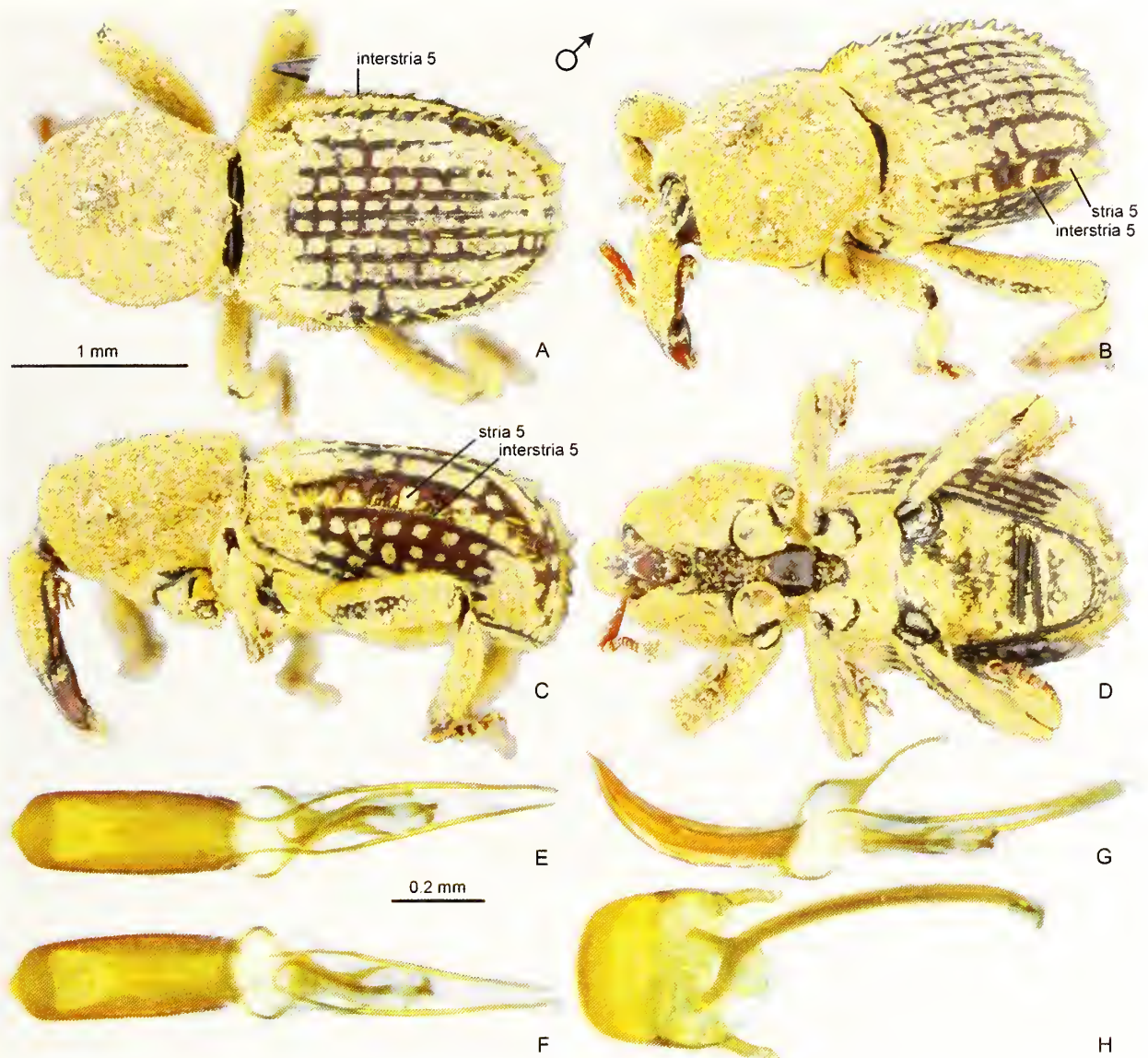


Fig. 8. *Paocryptorrhinus* sp. #3801, #3801 from East Usambara, male. A–D: habitus; E–G: aedeagus and tegmen, dorsal (E), ventral (F), lateral (G); H: tergite 8 and sternite 9, ventral.

***Paocryptorrhinus* sp. #3081**

Figs 8, 9G

Diagnosis. This species is unique by having markedly widened elytral striae 4 and 5 (Fig. 8C).

Description. Male (Fig. 8, 9G). GenBank accession: KJ672257. Length: 3.10 mm. Greater prosternal postcoxal flanges forming rostral canal subequal in depth to that anterior of procoxae; raised elytral interstriae 1 to 6 reaching elytral base, subequal in height; lateral elytral outline in dorsal view formed by ridge on interstria 5; elytral striae 4 and 5 markedly wider than others; hind femur without ventral tooth.

Material examined. Male (CNC): #3081, “TANZANIA, E Usambara Mts., Amani NR, 5°05'56"S 38°37'18"E, 16.xii.2011, 970m, sift.07, V.Grebennikov”.

Distribution. This species is known from a single specimen found in East Usambara, northeastern Tanzania. Elevation: 970 m.

Remarks. Unlike *P. lachesis* sp. n. also known from a male singleton, this potentially new species is consciously left unnamed, mainly due to uncertainties suggested by its geographical proximity to the majority of other species of *Paocryptorrhinus*.

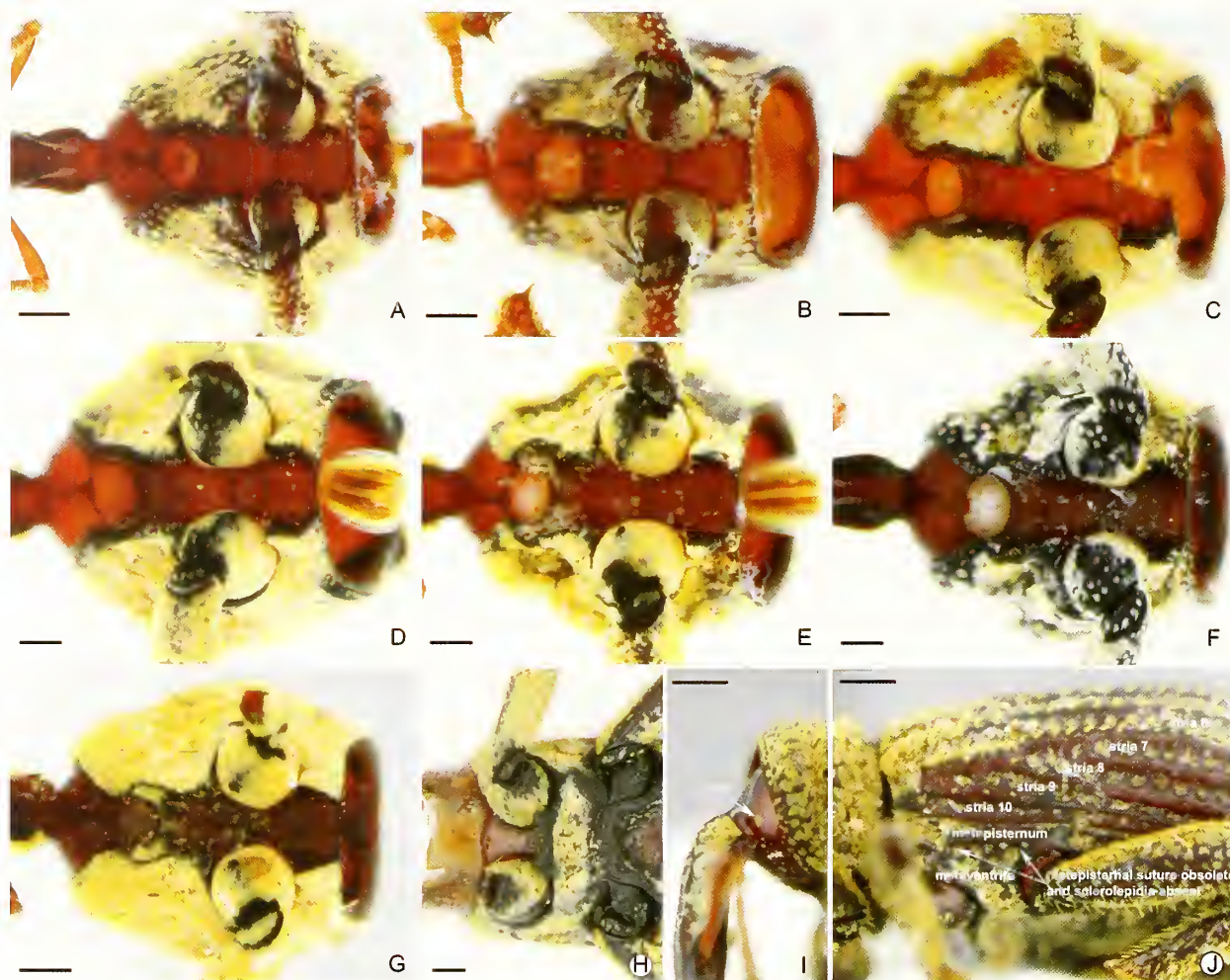


Fig. 9. *Paocryptorrhinus* spp., ventral view. (A–G): prothorax in ventral view showing prosternal canal and variously developed postcoxal flanges forming its lateral walls; (H): meso- and metaventrums with two basal abdominal ventrites in ventral view showing rostral canal and its posterior vertical wall formed by metaventrums; (I): head in left lateral view showing small eye; (J): left elytron and left metathorax showing lack of metepisternal suture and sclerolepidia. (A): *P. hustachei* comb. n., #4893 from Mt. Kilimanjaro, male; (B): *P. hanangensis* sp. n., #5086 from Mt. Hanang, female; (C): *P. atropos* sp. n., #7271 from North Pare, female; (D, H): *P. atropos* sp. n., holotype, #5438 from South Pare, male; (E): *P. clotho* sp. n., #5476 from West Usambara, female; (F) *P. lachesis* sp. n., holotype, #3603 from Kimboza Forest, male; (G): *Paocryptorrhinus* sp. #3081, #3081 from East Usambara, male; (I, J): *P. hustachei*, #4801 from Mt. Kilimanjaro, unsexed. Scale: 0.2 mm.

RESULTS OF DNA ANALYSES

The model search in MEGA6 detected the generalized time-reversible model with gamma distributed rate heterogeneity and inferred proportion of invariable sites (GTR+G+I) as the best fit. The best ML tree (not shown and with *Paocryptorrhinus* branching pattern identical to that in Fig. 10) had the highest log likelihood of -7223.19 . The representatives of *Paocryptorrhinus* were not monophyletic being separated in two clades, *P. hustachei* comb. n. plus *P. hanangensis* sp. n. versus all other species, respectively (as in Fig. 10). The BEAST analysis (Fig. 10) recovered a topology identical to that of the ML analysis, although the exact placement of both ingroup

clades among the members of the extended outgroup was different. The time tree hypothesis from BEAST revealed for the *Paocryptorrhinus* evolution an interval from 14.16 MY to present (Fig. 10).

DISCUSSION

While the present report greatly increases the amount of information available on *Paocryptorrhinus* weevils, all attempts to interpret the results are still much hindered by the acute shortage of data and concomitant phylogenetic resolution. The results, therefore, should be taken with caution.

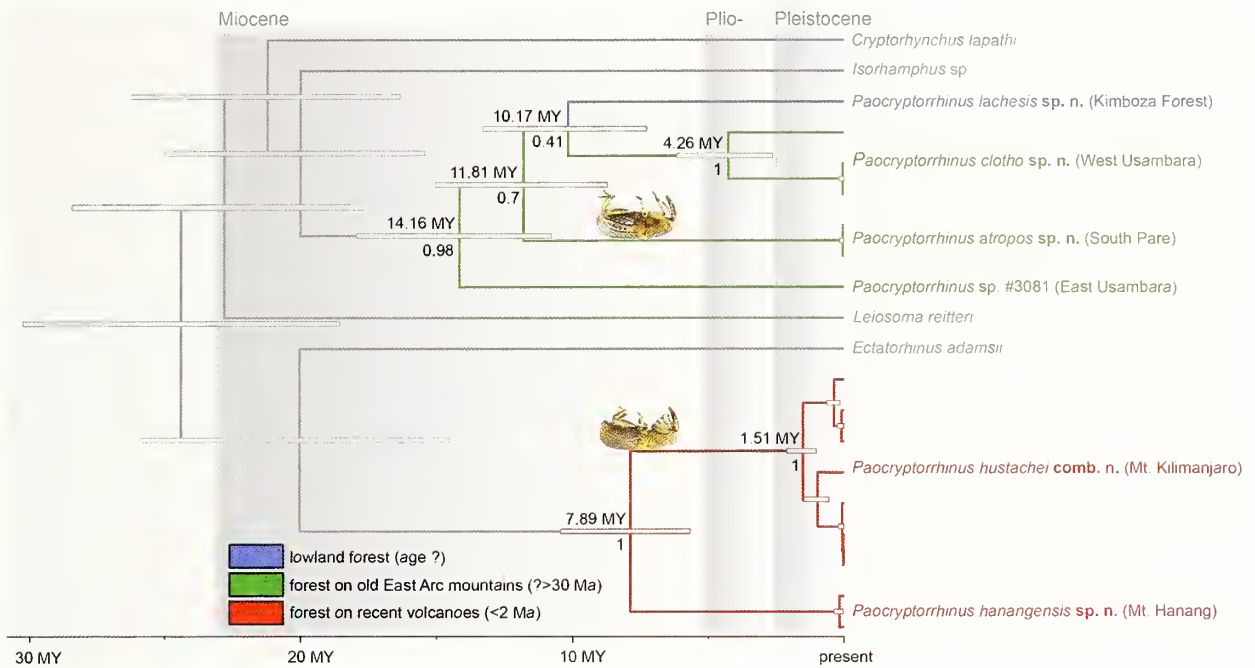


Fig. 10. Relevant part of an ultrametric time tree of *Paocryptorrhinus* obtained by using BEAST software calibrated at a rate 0.018 substitutions/site/MY. Note that the genus was not recovered as monophyletic. Values above nodes and on scale below are million years before present (MY); values below nodes are bootstrap support for identical clades recovered in ML analysis. Node bars represent 95% confidence interval of the age estimate.

Monophyly of *Paocryptorrhinus*

Even though monophyly of *Paocryptorrhinus* was rejected in both DNA analyses (Fig. 10), the genus is likely monophyletic. This assumption is based on three independent sources of evidence. The seemingly strongest support comes from rather uniform adult morphological characters: the similar unique arrangement of sclerites forming the rostral canal (Figs 7A–B, 9A–H) potentially represents a complex synapomorphy. The small adult eyes formed by a seemingly single and relatively flat ommatidium might be another synapomorphy. The deep retraction of the head capsule into pronotum (Fig. 1), lateral constriction of the pronotum in apical fourth, and the peculiar sclerotization of the endophallus (Fig. 2E) might be other synapomorphies. Thus, a broadly designed morphology-based phylogenetic analysis, presently outside of the scope of this study, has the potential of recovering the genus as a monophyletic clade. Such a hypothesis could be coherent with two other lines of evidence: (a) the similar biological preferences (=inhabitants of wet leaf litter in primary forests), and (b) the restricted distribution of the genus, with all species limited to northeastern Tanzania (Fig. 11).

Phylogenetic position of *Paocryptorrhinus*

The sister group of *Paocryptorrhinus* and its phylogenetic position among other weevils are presently entirely unknown. The genus was described as a member of “Notarini” and was retained there ever since (although under a different tribe name of Brachycerinae: Eriirhinini; see Alonso-Zarazaga & Lyal 1999). This assignment is rather an historical artefact than an evidence-based hypothesis. When described by Voss, *Paocryptorrhinus* was only compared with the genus *Pachytychius* Jekel, which then was kept in Brachycerinae: Eriirhinini. The latter genus, however, was transferred from Eriirhinini to Curculioninae, and retained either in Storeini (Alonso-Zarazaga & Lyal 1999) or *incertae sedis* (Caldara et al. 2014). Consequently, the original assignment of *Paocryptorrhinus* to Eriirhinini via its similarity with *Pachytychius* was the only reason why the former remained in Brachycerinae: Eriirhinini (although with some reservations; see Oberprieler 2014).

The current assignment of *Paocryptorrhinus* to Eriirhinini is not corroborated in the present analysis (Fig. 10), since *Paocryptorrhinus* did not form a clade with *Notaris*, the latter being the type genus of Eriirhinini. This is not surprising, since adults of *Paocryptorrhinus* neither display the pedotectal-type of male genitalia characteristic

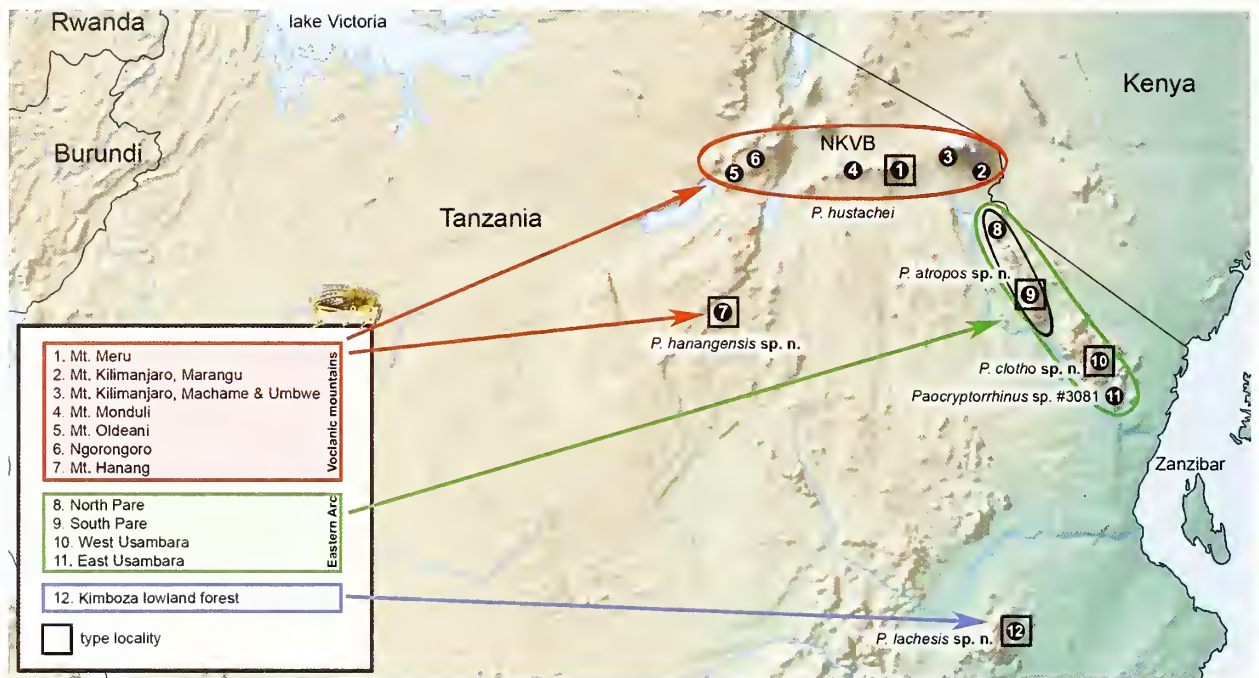


Fig. 11. Known distribution of *Paocryptorrhinus* weevils. NKVB: Ngorongoro-Kilimanjaro Volcanic Belt.

to *Notaris* and most Brachycerinae, nor do they have a lateral setiferous groove on either side of the rostral apex characteristic for most of Erihrinini (Oberprieler 2014, Figs 3.7.1.2D–G). The presence of prosternal postcoxal flanges forming lateral walls of the rostral canal seemingly suggests affinities to Molytinae: Aedemonini, a group of 35 genera from most of the warm and temperate regions of the World (except Europe, New Zealand and both Americas; Lyal 2014). Unlike adults of Aedemonini, those of *Paocryptorrhinus* have a rostral canal with a markedly developed transverse posterior metaventral wall (Figs 7I, J) and the posterior margin of the male tergite 7 is only weakly emarginated (Fig. 2I). Alternative states of these two characters were suggested as synapomorphies for Aedemonini (Lyal 2014) and, therefore, this tribe cannot accommodate *Paocryptorrhinus*. Any attempt to place the genus in the relatively weakly understood phylogenetic framework of weevils is at present doomed by the lack of adequate data and pre-existing hypotheses. With all this in mind, the most rational temporal action is the herein proposed transfer of the genus from Brachycerinae: Erihrininae to Molytinae *incertae sedis*.

Phylogeography of *Paocryptorrhinus*

Adults of *Paocryptorrhinus* are most likely low-dispersing and humidity-dependant, specialized litter inhabitants, as suggested by sampling circumstances, flightlessness, and eye reduction. As presently known, all species of *Paocryptorrhinus* are strictly allopatric (Fig. 11) and all are found within a coherent geographical area in north-

eastern Tanzania (Fig. 11). These observations appear to favour the simplified model of vicariant speciation for low-dispersing habitat-dependent organisms (but see below on *P. hustachei* comb. n. and *P. hanangensis* sp. n.). Remarkably, the genus *Paocryptorrhinus* has not been detected by us in other seemingly suitable and similarly extensively sampled parts of the Eastern Arc Mountains in Tanzania, such as Nguru, Kaguru, Rubeho, Udzungwa and Uluguru. The lack of *Paocryptorrhinus* records from Uluguru is particularly puzzling, since the forest edge is only 10 km west of the minute (about 3 km square) Kimboza forest, the type locality of *P. lachesis* sp. n.

Among all species, *P. hustachei* comb. n. has the largest known distribution on forested slopes of five volcanic mountains forming a nearly straight latitudinal chain some 220 km long: Mt. Kilimanjaro, Mt. Meru, Mt. Mulundi, Mt. Oldeani and the adjoining Ngorongoro highlands (NKVB, Fig. 11). Only Mt. Kilimanjaro specimens from two localities (Fig. 11) were available for DNA analysis (Fig. 10), while morphological similarity was the main criterion to group all specimens into a single species, including those not barcoded. A similar approach was used with morphologically homogenous *P. atropos* sp. n. known from North and South Pare mountains, but only the latter locality was represented on the DNA-based topology. The ancient lowland or Eastern Arc Mountains in Tanzania were long believed to harbour numerous ancient moisture-dependent low-dispersal animals (Tolley et al. 2011 and references therein), such as *Paocryptorrhinus* weevils. The presence of two species in the geologically young forests on volcanic cones (Fig. 11) is, therefore, a remark-

able result strongly implying their relatively recent colonization. The same species grouping (i.e. those from old versus young forests), is upheld with the ML and Bayesian phylogenetic trees (Fig. 10), and morphologically (see the first couplet of the key). Only a few other similarly habitat-dependent and locally abundant radiations such as horned chameleons (Ceccarelli et al. 2014), brevicipitid frogs (Loader et al. 2014) or bush crickets (Hemp et al. 2014 and references therein) were studied in sufficient detail and to evaluate distributional patterns, which were found to be similar to that reported for *Paocryptorrhinus*.

Equally remarkable is the fact that the split between both species inhabiting young forests on volcanic highlands is dated at 7.89 MY (Fig. 10). This is about four times older than the origin of these mountains and, subsequently, predates the origin of the wet forest habitat suitable for these beetles. The last observation strongly suggests that (A.) separation between *P. hustachei* comb. n. and *P. hanangensis* sp. n. is not attributable to their currently observed allopatry (Fig. 11) and that (B.) the most recent common ancestor of each of these two species had means to colonize both localities across presently unsuitable dry savannah landscapes. A similar phenomenon was hypothesized for a radiation of flightless *Galapaganus* Lanteri endemic to, and markedly older than, the Galápagos Islands (Sequeira et al. 2000).

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Species richness of termites (Blattoidea: Termitoidea) and ants (Hymenoptera: Formicidae) along disturbance gradients in semi-arid Burkina Faso (West Africa)

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Abstract. From 2004 to 2008, we conducted the first inventory of termites (Blattoidea: Termitoidea) and ants (Hymenoptera: Formicidae) in Burkina Faso (West Africa) where these important ecosystem engineers are the only active, quantitatively remarkable soil macrofauna during a long dry season. We combined two standard assessment protocols for tropical forests and adapted them to semi-arid (agro)ecosystems to representatively characterize termite and ant communities in two agricultural systems, and assess their response to land-use intensification. In total, 65 ant species and 41 termite species were collected along parallel transects replicated during consecutive years. Both taxa were highly sensitive to human impact. Their taxonomic and functional richness strongly decreased with increasing intensification from a near-natural savannah towards cotton fields with recent pesticide application (North Sudan region), and recovered along a succession of the traditional rehabilitation technique Zaï from barren, crusted land towards a long-term fallow with diverse flora and fauna (sub-Sahel region). Fungus-growers dominated the termite communities in all habitats, with the highest variations between habitats noted among soil- and grass-feeders.

Key words. Soil fauna, community composition, anthropogenic impact, land-use gradient, traditional soil restoration, sampling protocol.

INTRODUCTION

Termites (Blattoidea: Termitoidea) and ants (Hymenoptera: Formicidae) are of extraordinary ecological and economic importance throughout the tropics and subtropics, particularly amid arid and infertile environments (Evans et al. 2011; Lee & Foster 1991). In Burkina Faso (West Africa), termites and ants are the only active, quantitatively remarkable soil macrofauna during the long dry season (Rouland et al. 2003; Schuurman 2006). Their richness and abundance may be severely affected by land-use practices (for example, see reviews of Davies et al. 2003; Hölldobler & Wilson 1990; Lobry de Bruyn 1993). Agricultural practices are a leading cause of biodiversity loss (Green et al. 2005; Millennium Ecosystem Assessment 2005) and land degradation (Bai et al. 2008). Particularly existential are the consequences in sub-Saharan Africa where millions of people depend on agriculture for their livelihoods and where vast areas are covered with degraded, barren soils (Batjes 2001). One approach to develop more sustainable agriculture is to harness ecosystem services of naturally occurring organisms (Evans et al. 2011). Termites and ants are major examples for soil-dwelling

'ecosystem service providers' (Jouquet et al. 2014) that influence ecosystem functioning by physically altering their biotic and abiotic surroundings (Jones et al. 1997). Both taxa contain species that may become a pest in agricultural systems; however, they are far more often beneficial, especially in dryland agriculture (Evans et al. 2011). Through soil turnover (tunnelling and sheeting production) during their foraging and nesting activities, termites and ants further the soil's aeration, enhance absorption and storage of water in soils, and facilitate carbon fluxes and storage (for example, Lobry de Bruyn & Conacher 1990; Sileshi et al. 2010). An impressive example of a traditional soil water conservation method in semi-arid West Africa, making use of the positive effects termites exert on soil properties, is the Zaï practice (Kaboré & Reij 2004; Reij et al. 2009b).

Despite a widespread recognition of the major importance of termites and ants in arid and nutrient-poor environments, nothing was known about either their actual diversity in Burkina Faso or the effects of the ongoing human-induced changes on the composition of their communities. Most studies in West Africa concentrated on forests, the few in savannahs and agroecosystems were



Fig. 1. The geographic location of Burkina Faso in West Africa and of the two study regions – the Yatenga Province in the sub-Saharan zone (1), and the Gourma Province in the North Sudan region (2).

conducted in humid regions, such as the Comoé NP and the Lamto Reserve in the Côte d'Ivoire (Dosso et al. 2013; Konaté & Kampmann 2011; Kone et al. 2012; TraBi 2013; Yéo et al. 2011). We, therefore, selected two traditional agricultural systems characteristic for the region in focus and assessed the invertebrate's diversity between 2004 and 2008. We combined two well-established standard protocols for sampling termites and ants in tropical forests, and adapted them to semi-arid savannahs and agroecosystems. This newly revised protocol has proven highly efficient in representatively assessing and monitoring the termite and ant fauna.

MATERIAL AND METHODS

Study regions

We selected two traditional agricultural systems characteristic for the two main phytogeographic regions in Burkina Faso, each representing a disturbance gradient

comprising four distinct habitats, presently differing in the magnitude of human intervention but formerly having the same initial state.

Disturbance gradient in the Yatenga Province (sub-Saharan zone). As the first land-use intensification gradient, we selected a temporal cross-section of the traditional restoration system Zaï in Ouahigouya (Yatenga Province) in the sub-Saharan region (altitude 336 m) (Fig. 1, Table 1). The climate is characterized by a rainy season of four to five months and a long dry season with high temperatures (UNESCO 1977). Between 1998 and 2008, the mean annual rainfall was about 660 mm, the mean monthly temperature varied between 19.1°C and 39.1°C.

In the Zaï practice, the farmers dig pits (microwatersheds) in parallel rows; shortly before the first rains, they put crop seeds and air-dried compost into the pits. Each farmer adapts the pits to his farm conditions (pit number, dimensions, quantity of compost) (Hien & Ouedraogo 2001). Some use Zaï to intensify cereal production, others for reforestation, or both (Reij et al. 2009a). The or-

Table 1. Abbreviation, characteristics and history of study sites chosen in Burkina Faso (for each gradient, sorted according to increasing human impact).

First disturbance gradient: four age-stages of the Zaï system in the sub-Sahel region	
ZF30	<i>Old Zaï forest</i> (13°32'25"N; 2°22'57"W). In 2009: 30-year Zaï restoration. First cultivated for four years, then 26 years fallow; diverse woody and herbaceous vegetation; mostly thin but closed canopy; topsoil sandy loam.
ZF20	<i>Young Zaï forest</i> (13°32'34"N; 2°22'55"W). In 2009: 20-year Zaï restoration. First cultivated for four years, then 16 years fallow; diverse woody and herbaceous vegetation but still degraded areas; mostly open canopy; topsoil loam.
ZMil	<i>Millet fields</i> (13°32'29"N; 2°23'07"W). In 2009: both fields 11-year Zaï cultivation; millet and green beans. At the time of sampling, the fields were in the fifth, seventh and eighth year; topsoil loam.
ZDeg	<i>Degraded, barren area</i> (13°32'36"N; 2°22'59"W). Initial stage of all Zaï stages; two plots of ferruginous, infertile Lithosol; barren, crusted and impermeable surface; no vegetation; topsoil sandy loam.
Second disturbance gradient: four land-use types in the North Sudan region	
FRes	<i>Pama reserve</i> (11°38'26"N; 0°31'45"E). Initial stage of all North Sudanese habitats; two plots of protected arboreous and shrubby savannah; open canopy; dense grass sods; managed by annual fire; topsoil sandy loam.
FPas	<i>Pasture area</i> (11°38'40"N; 0°30'03"E). In 2009: exclusively used for grazing cattle since 20 years; most areas with isolated trees and bushes; some barren spots; topsoil sandy loam.
FFal	<i>Short-term fallow</i> (11°38'17"N; 0°30'09"E) from 2003–2006. In 2009: 19 years. At the time of sampling: second and fourth year fallow. Before fallowing, crop rotation practised every third year, including cotton for four years. All trees had been felled; dense grass-cover; topsoil clayey loam.
FCot	<i>Cotton fields</i> (11°38'15"N; 0°30'27"E). Two fields, in 2009 both 13 years. At the time of sampling: second year cotton cultivation; crop rotation practiced every third year including four years cotton with extensive use of different pesticides (Fanga 500EC, Caiman 500EC, Calthio E, Capt 88EC, Attakan C344SE, Rocky C386EC, Sherphos 230EC) and 200 kg commercial fertilizer per hectare; topsoil loam.

Soil texture was analysed in 3–7 composite samples of the habitat's topsoil (0–10 cm).

ganic matter attracts termites which construct galleries in the crusted soil to commute between the food source and the nest, thereby increasing the soils' aeration, water infiltration and water holding capacity (Roose et al. 1993).

We selected four age-stages (for the characteristics, see Table 1). An old forest of about 30 years of age (ZF30, Fig. 2A) and a younger one about 20 years old (ZF20, Fig. 2B) represented the reforestation (fallow) phase. Two millet fields (ZMil, Fig. 2C) were selected for the cropping period, and two barren, crusted areas (ZDeg, Fig. 2D) for the initial stage. Each site lay within a radius of 300–400 m of the other and comprised an area of about 1 hectare.

Disturbance gradient in the Gourma Province (North Sudan region). The second disturbance gradient was chosen 52 km south of Fada N'Gourma (Gourma Province) in the North Sudan region (altitude 253 m) (Fig. 1, Table 1). The rainy season lasts from around mid-April till October (Some et al. 2006). Between 1997 and 2008, the mean annual rainfall in Fada N'Gourma was about 875 mm, the mean monthly temperature ranged between 19.6°C and 37.1°C. The natural vegetation is of the savannah type (UNESCO 1977).

Two plots in the Pama reserve (FRes, Fig. 2E) with an area of 1 km² each represented the characteristic near-natural savannah habitat for the region (A Thiombiano, Ouagadougou, pers. comm. 2004) and the initial habitat stage of this disturbance gradient. A pasture (FPas, Fig. 2F), a short-term fallow (FFal, Fig. 2G) and two cotton fields (FCot, Fig. 2H) were chosen in a rural area separated from the park border by a street. Each plot had a size of about 1 hectare.

The characteristics of each habitat are summarized in Table 1.

The baseline sampling protocol

Our rapid assessment protocol (RAP) (Fig. 3) was based on two widely accepted standard protocols – the protocol of Agosti & Alonso (2000) for ants in the leaf litter and the transect protocol of Jones & Eggleton (2000) for termites in tropical forests. The protocols were combined and adjusted to account for the conditions prevailing in our semi-arid agroecosystems; for example, only negligible amounts of litter covered the ground and most sites had an area of 1 hectare only.



Fig. 2. Study sites in the A–D) sub-Sahel zone, and E–H) North Sudan region. A: old Zai forest (ZF30; one plot); B: young Zai forest (ZF20; one plot); C: millet field (ZMil, two plots); D: degraded, barren area (ZDeg; two plots); E: Pama reserve (FRes; two plots); F: pasture area (FPas; one plot); G: short-term fallow (FFal; one plot); H: cotton fields (FCot; two plots).

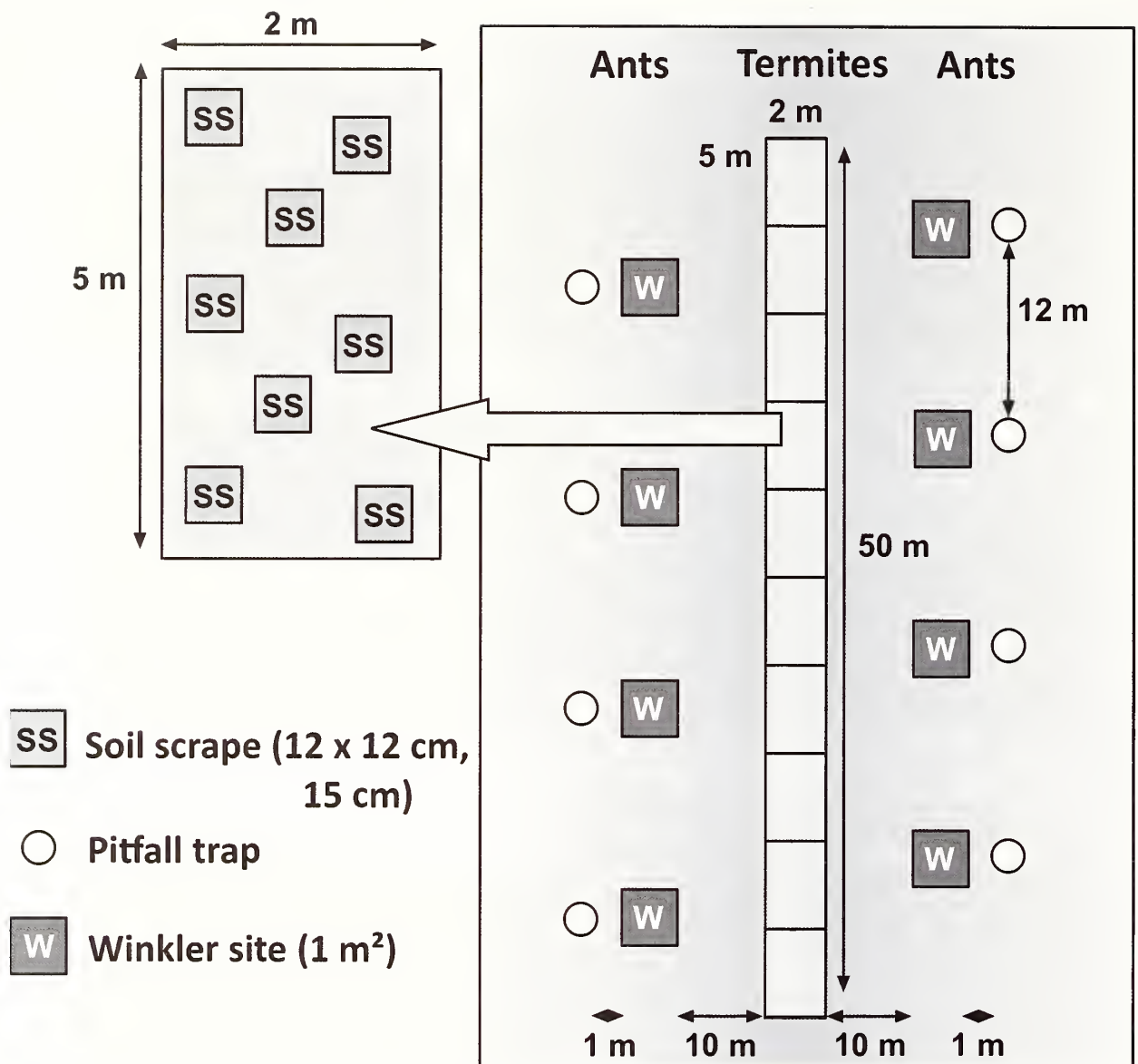


Fig. 3. Relative position of sampling sites according to the combined and standardized rapid assessment protocol (RAP), followed to assess termite and ant communities.

For termites, the RAP included 10 contiguous 5 x 2 m sections resulting in a transect length of 50 m. The first transect in each habitat had a length of 100 m as in Jones & Eggleton (2000), but many of those run in 1 hectare plots had to be divided into two parallel parts. In each section, termites were first searched in as many different microhabitats as possible (such as accumulations of litter, inside and underneath dead logs and twigs, epigeal mounds and runways on vegetation). Then, eight samples of surface soil ('soil scrapes'), each 12 x 12 cm and 15 cm deep, were taken at random locations and searched *in situ*. The sampling time per section was 1 man-hour; stopping rules

applied if no microhabitats could be found, resulting in a shorter sampling time.

Ants were collected on parallel transects in a distance of 10 m on both sides of the termite transect at eight sampling sites (four on each side every 12 m). Within an area of 1 m² the vegetation was at first searched for ants and thereupon totally removed, and all ants walking on the ground were collected for a duration of five minutes (called 'Winkler-site'). It substituted the mini-Winkler extractor of Agosti & Alonso (2000), which was applied during the first year but failed to capture most of the ants due to the limited amounts of litter in our study sites. In a

1 m distance, pitfall traps with a diameter of 10 cm were buried in the soil and filled with 45% ethanol; they were run for 48 hours. Following the newly revised RAP, ants were additionally collected when encountered in the sections of the belt-transects, i.e. in microhabitats and soil scrapes. For a detailed description and illustration of the working steps, please refer to Kaiser et al. (2011) and Kaiser (2014), the relative position of sampling sites according to the combined assessment protocol is illustrated in Fig. 3.

Species identification. Specimen of both taxa were stored in vials with 90% ethanol; they were identified to the level of species or, whenever this was impossible, to numbered morphospecies – ants by using the taxonomic works of, for example, Bolton (1994, 1995) and Bolton et al. (2007); termites following Bouillon & Mathot (1965), Emerson (1928), Sands (1998), and Webb (1961); and both with reference to collections from West Africa held in the research station in Lamto NP (University Nangui Abrogoua, Côte d'Ivoire). Own reference collections were assembled for both taxa and will be stored in the Naturmuseum Senckenberg (Frankfurt am Main, Germany). However, presently we still work with the collection in the research unit on ecology and biodiversity, UREB (Prof. Souleymane Konaté), University Nangui Abrogoua (Abidjan, Côte d'Ivoire). According to their diet and mandible morphology (Deligne 1966) and following Grassé (1986), termite species were assigned to one of these four functional groups: soil-feeders, wood-feeders, grass-feeders and fungus-growers.

All data presented here originate from three to four transects conducted in each land-use type in the rainy seasons between 2004 and 2008. Four replicate transects were run in the Zaï stages (sub-Sahel zone) and the Pama reserve, three in the other habitats of the North Sudan region.

Statistical analyses

Species accumulation and rarefaction curves

Incidence-based species accumulation curves were used to graphically compare the species richness of the habitats belonging to the same disturbance gradient. When the sampling effort differed between the habitats to be compared (for example, in the North Sudan region), the rarefaction method was used to calculate the number of species expected in a subsample randomly selected from multiple samples (Chiarucci et al. 2008; Koellner et al. 2004). Smoothed curves were produced by randomizing the data 500 times. The slopes of the curves illustrate the rate at which new species were added with an increasing sampling effort. The increasing sampling effort was equivalent with an increasing number of a) transect sections for termites and b) sampling units, each comprising one transect section, one pitfall trap and one Winkler quadrat in

the case of ants. The software EstimateS Version 7.51 for Windows (Colwell 2005) was used to calculate the species accumulation and rarefaction curves.

Comparisons among study sites

The software SPSS 15.0 (SPSS Inc. 2006) was used for comparisons between the different habitats concerning their species composition and the number of species observed (or expected at the common sampling effort). Friedman's ANOVA was used to compare land-use types belonging to the same gradient. The Wilcoxon sign-rank test was used for pairwise comparisons between related land-use types. The Bonferroni correction was applied afterwards to adjust the level of significance.

Disturbance index

To analyse the correlation between species richness and habitat disturbance, we combined the data of both regions and assigned each habitat type to one of the four disturbance classes (ordinal scale), with a disturbance index of 1 used for the near-natural habitats (old Zaï Forest and Pama reserve), 2 for pasture land and fallows (young Zaï Forest, short-term fallow), 3 for agricultural plots (millet fields, cotton fields) and 4 for fully degraded, barren land.

A linear regression was then performed in SPSS 15.0 (SPSS Inc. 2006) with the number of a) ant species and b) termite species collected per site and plot as the dependent variable, and the disturbance index and study region as independent ones. The study region was defined as a nominal variable with 1 for the sub-Sahel zone and 2 for the North Sudan zone.

RESULTS

Combining the sites of both regions, 65 ant species (25 genera and nine subfamilies) and 41 termite species (13 genera and four subfamilies) were collected between 2004 and 2008.

Species checklists

Ant communities

A checklist of all ant species present in the different land-use types is given in Table 2. The lowest species, genus, and subfamily numbers were found in highly-intensified areas, the degraded land in the sub-Sahel zone and the cotton fields in the North Sudan region. The ant fauna in Burkina Faso was dominated by the Myrmicinae, which comprised 54% of the total number of species collected along both disturbance gradients, followed by the Formicidae (22%) and the Ponerinae (9%).

Table 2. Ant (morpho)species present (X) in the Zaï stages in Ouahigouya (sub-Sahel zone) and in the habitats near Fada N'-Gourma (North Sudan region).

Ants in Burkina Faso Subfamily, genus & species name	ZF30	Sub-Sahel zone			FRes	North Sudan region		
		ZF20	ZMil	ZDeg		FPas	FFal	FCot
PROCERATIINAE								
<i>Probolomyrmex</i> Mayr, 1901								
<i>P. sp.01</i>	—	—	—	—	X	—	—	—
PONERINI								
<i>Anochetus</i> Mayr, 1861								
<i>A. sedilloti</i> Emery, 1884	X	X	X	X	X	—	—	—
<i>A. sp.02</i>	X	X	—	X	—	—	X	—
<i>Leptogenys</i> Roger, 1861								
<i>Leptogenys sp.01</i>	—	—	—	—	—	X	X	—
<i>Pachycondyla</i> Smith, 1858								
<i>P. senaarensis</i> (Mayr, 1862)	X	X	X	—	X	X	X	X
<i>P. sp.01</i>	—	—	—	—	X	X	X	X
<i>P. sp.03</i>	X	—	—	—	X	—	—	—
AENICTINAE								
<i>Aenictus</i> Shuckard, 1840								
<i>A. sp.01</i>	—	—	—	—	X	—	X	—
DORYLINAE								
<i>Dorylus</i> Fabricius, 1793								
<i>D. sp.01</i>	—	—	—	—	X	—	X	—
<i>D. sp.02</i>	X	—	—	X	—	—	X	—
<i>D. sp.03</i>	—	—	—	—	X	X	X	—
MYRMICINAE								
<i>Crematogaster</i> Lund, 1831								
<i>C. sp.01</i>	—	—	—	—	X	—	—	—
<i>C. sp.02</i>	—	X	X	X	—	—	X	X
<i>C. sp.03</i>	—	—	—	X	—	—	—	—
<i>Cardiocondyla</i> Emery, 1869								
<i>C. sp.03</i>	—	—	—	—	—	X	X	—
<i>C. sp.04</i>	—	—	—	—	—	—	X	—
<i>Nesomyrmex</i> Mayr, 1855								
<i>N. evelynae</i> (Forel, 1916)	—	X	—	—	—	—	—	—
<i>Temnothorax</i> Mayr, 1861								
<i>T. megalops</i> (Hamann & Klemm, 1967)	X	X	—	—	—	—	—	—
<i>Meranoplus</i> Smith, 1853								
<i>M. sp.01</i>	—	—	—	—	X	X	X	—
<i>Myrmecaria</i> Saunders, 1841								
<i>M. sp.01</i>	—	—	—	—	X	—	—	—
<i>Messor</i> Forel, 1890								
<i>M. galla</i> (Emery, 1895)	—	—	—	—	X	—	X	X
<i>Pheidole</i> Westwood, 1839								
<i>P. sp.01</i>	X	X	X	X	X	X	X	X
<i>P. sp.02</i>	X	—	—	—	X	X	X	X
<i>P. sp.03</i>	X	X	X	—	—	X	X	X
<i>P. sp.04</i>	—	—	—	—	X	X	X	X
<i>Monomorium</i> Mayr, 1855								
<i>M. abyssinicum</i> (Forel, 1894)	X	X	X	—	X	X	X	—
<i>M. areniphilum</i> (Santschi, 1911)	—	—	—	X	—	—	—	X
<i>M. bicolor</i> Emery, 1877	X	X	X	X	X	X	X	X
<i>M. dakareense</i> (Santschi, 1914)	X	—	—	—	—	—	—	—

Ants in Burkina Faso Subfamily, genus & species name	ZF30	Sub-Sahel zone			FRes	North Sudan region		
		ZF20	ZMil	ZDeg		FPas	FFal	FCot
<i>M. destructor</i> (Jerdon, 1851)	X	–	–	X	X	–	–	–
<i>M. oscaris</i> Forel, 1894	X	X	X	–	X	–	–	–
<i>M. sp.01</i>	X	–	–	–	–	–	–	–
<i>M. sp.08</i>	X	–	–	–	–	X	X	–
<i>M. sp.09</i>	X	X	X	X	–	–	X	–
<i>M. vonatu</i> Bolton, 1987	X	X	X	X	–	X	X	–
<i>Oligomyrmex</i> Mayr, 1867								
<i>O. sp.01</i>	–	–	–	–	X	–	–	–
<i>O. sp.02</i>	X	–	–	–	X	–	–	–
<i>Tetramorium</i> Mayr, 1855								
<i>T. angulinode</i> Santschi, 1910	X	X	X	X	X	X	X	X
<i>T. longicorne</i> Forel, 1907	X	–	–	–	–	–	–	–
<i>T. sericeiventris</i> Emery, 1877	X	X	X	X	X	X	X	X
<i>T. sp.05</i>	X	–	–	–	–	–	–	–
<i>T. sp.06</i>	X	X	X	–	X	X	X	–
<i>T. sp.07</i>	–	X	X	–	–	–	–	–
<i>T. sp.08</i>	–	–	–	–	–	X	–	–
<i>T. sp.10</i>	–	–	–	–	–	X	–	–
<i>T. zapyrum</i> Bolton, 1980	X	–	X	–	–	X	–	–
DOLICHODERINAE								
<i>Tapinoma</i> Foerster, 1850								
<i>T. sp.01</i>	X	X	X	–	X	–	X	X
<i>T. sp.02</i>	–	X	X	–	–	–	–	–
AMBLYOPONINAE								
<i>Amblyopone</i> Erichson, 1842								
<i>A. sp.01</i>	–	–	–	–	–	–	X	–
CERAPACHYINAE								
<i>Cerapachys</i> Smith, 1857								
<i>C. sp.01</i>	X	–	–	–	–	–	–	–
<i>C. sp.02</i>	–	–	–	–	X	–	–	–
FORMICINAE								
<i>Anoplolepis</i> (Santschi, 1914)								
<i>A. sp.01</i>	X	X	–	–	–	–	–	–
<i>A. sp.02</i>	–	–	–	–	X	–	–	–
<i>Lepisiota</i> (Santschi, 1926)								
<i>L. sp.01</i>	X	X	X	–	X	X	X	–
<i>L. sp.02</i>	X	X	X	–	X	–	X	–
<i>L. sp.03</i>	X	–	X	X	–	–	X	–
<i>Cataglyphis</i> Foerster, 1850								
<i>C. sp.01</i>	–	–	–	–	X	X	X	X
<i>Camponotus</i> Mayr, 1861								
<i>C. compressiscapus</i> André, 1889	–	–	–	–	X	X	X	X
<i>C. maculatus</i> (Fabricius, 1782)	X	X	X	X	X	X	X	X
<i>C. sericeus</i> (Fabricius, 1798)	X	X	X	–	X	X	X	X
<i>C. solon</i> (Forel, 1886)	–	–	–	–	X	X	–	–
<i>C. sp.06</i>	–	–	–	–	X	X	X	X
<i>C. sp.07</i>	X	–	–	–	X	X	X	X
<i>Polyrhachis</i> Smith, 1857								
<i>P. sp.01</i>	–	–	–	–	X	–	–	–
<i>P. sp.02</i>	X	X	–	–	–	–	–	–
Species number observed	35	25	22	15	37	28	36	19

Land-use types: old Zaï forest (ZF30), young Zaï forest (ZF20), millet fields (ZMil), degraded area (ZDeg); near-natural savannah (FRes), pasture area (FPas), short-term fallow (FFal), cotton fields (FCot).

Table 3. Termite (morpho)species present (X) in the habitats in Ouahigouya (sub-Sahel zone) and near Fada N'Gourma (North Sudan region). A two-digit shortcut before the genus name indicates the functional group to which it belongs to: fungus-growers (fg), grass-feeders (gf), soil-feeders (sf), wood-feeders (wf), unknown (uk).

Ants in Burkina Faso		Sub-Sahel zone					North Sudan region		
Subfamily, genus & species name	ZF30	ZF20	ZMil	ZDeg		FRes	FPas	FFal	FCot
MACROTERMITINAE									
fg <i>Ancistrotermes</i> Silvestri, 1912									
<i>A. cavithorax</i> (Sjöstedt, 1899)	X	X	X	–		X	–	–	–
<i>A. crucifer</i> (Sjöstedt, 1897)	X	–	X	–		X	–	X	–
<i>A. guineensis</i> (Silvestri, 1912)	–	–	–	–		X	–	–	–
<i>A. sp.01</i>	–	–	–	–		–	X	X	–
fg <i>Macrotermes</i> Holmgren, 1909									
<i>M. bellicosus</i> (Smeathman, 1781)	X	X	–	–		X	X	X	–
<i>M. subhyalinus</i> (Rambur, 1842)	X	–	–	–		X	–	–	–
fg <i>Microtermes</i> Wasmann, 1902									
<i>M. havilandi</i> Holmgren, 1913	X	X	X	–		X	X	X	X
<i>M. sp.01</i>	X	X	X	–		–	–	–	X
<i>M. sp.02</i>	X	–	–	–		X	–	–	–
<i>M. subhyalinus</i> Silvestri, 1914	X	X	–	–		X	X	X	X
fg <i>Odontotermes</i> Holmgren, 1912									
<i>O. sp.01</i>	X	X	X	–		X	X	X	–
<i>O. sp.02</i>	X	X	–	–		–	X	X	–
<i>O. sp.03</i>	–	–	–	–		–	X	–	–
<i>O. sp.04</i>	–	X	–	X		–	–	–	–
NASUTITERMITINAE									
gf <i>Trinervitermes</i> Holmgren, 1912									
<i>T. geminatus</i> (Wasmann, 1897)	–	–	X	–		X	X	–	–
<i>T. graciosus</i> Sjöstedt, 1924	–	–	–	–		X	–	–	–
<i>T. occidentalis</i> (Sjöstedt, 1904)	X	–	–	–		X	–	–	–
<i>T. oeconomus</i> (Trägårdh, 1904)	X	X	X	–		X	X	X	–
<i>T. togoensis</i> (Sjöstedt, 1899)	–	–	–	–		X	–	–	–
<i>T. trinervius</i> (Rambur, 184)	–	–	–	–		X	–	–	–
wf <i>Fulleritermes</i> Coaton, 1962									
<i>F. coatoni</i> Sands, 1965	–	–	–	–		X	X	–	–
AMITERMITINAE									
wf <i>Amitermes</i> Silvestri, 1901									
<i>A. evuncifer</i> Silvestri, 1912	X	–	X	–		X	–	–	–
<i>A. guineensis</i> Sands, 1992	X	X	–	–		X	X	–	–
<i>A. messinae</i> Fuller, 1922	–	–	–	–		–	X	–	–
<i>A. sp.01</i>	X	–	–	–		–	–	–	–
<i>A. stephensoni</i> Harris, 1957	–	–	X	–		–	–	–	–
wf <i>Microcerotermes</i> Silvestri, 1901									
<i>M. edentatus</i> Emerson, 1928	X	X	X	–		X	–	X	–
<i>M. limpopoensis</i> Fuller, 1925	–	X	–	–		–	–	–	–
<i>M. parvulus</i> (Sjöstedt, 1911)	–	X	X	–		X	–	–	–
<i>M. parvus</i> (Haviland, 1898)	X	X	X	–		X	X	X	–
<i>M. theobromae</i> Holmgren, 1912	X	–	–	–		–	–	–	–
<i>M. thermanum</i> Fuller, 1925	–	X	–	–		–	–	–	–
TERMITINAE									
wf <i>Angulitermes</i> Sjöstedt, 1924									
<i>A. elsenburgi</i> (Fuller, 1925)	X	–	–	–		–	–	–	–
wf <i>Eremotermes</i> Silvestri, 1911									
<i>E. sabaeus</i> Harris, 1957	X	X	X	–		–	X	X	X
sf <i>Cubitermes</i> Wasmann, 1906									
<i>C. bilobatodes</i> Silvestri, 1912	–	–	X	–		–	–	–	–
<i>C. sp.01</i>	–	X	–	–		–	–	–	–
<i>C. subcrenulatus</i> Silvestri, 1914/15	X	–	X	–		X	–	–	–

Ants in Burkina Faso Subfamily, genus & species name	ZF30	Sub-Sahel zone			FRes	North Sudan region		
		ZF20	ZMil	ZDeg		FPas	FFal	FCot
sf <i>Promicrotermes</i> Silvestri, 1914/15 <i>P. holmgreni</i> (Silvestri, 1912)	–	–	–	–	–	–	X	–
APICOTERMITINAE								
sf <i>Anoplotermes</i> Sands, 1972 <i>A. sp.01</i>	X	X	–	–	X	–	–	–
UNKNOWN								
Unknown-sf	X	X	–	–	–	–	–	–
Unknown-1	X	X	X	–	X	–	X	X
Unknown-2	X	–	–	–	–	–	–	–
Species numbers observed	25	20	16	1	24	14	13	5

Land-use types: old Zaï forest (ZF30), young Zaï forest (ZF20), millet fields (ZMil), degraded area (ZDeg); near-natural savannah (FRes), pasture area (FPas), short-term fallow (FFal), cotton fields (FCot).

Together, the four Zaï stages hosted 41 ant species out of 16 genera and six subfamilies (Table 2). The number of species decreased with increasing human impact (decreasing habitat restoration) from 35 species (14 genera) in the old Zaï forest to 15 (nine genera) in the degraded area.

Ant assemblages in the North Sudanese sites were richer in species, genera, and subfamilies: 53 ant species out of 23 genera and nine subfamilies were found in total (Table 2). The number of species decreased with increasing land-use intensification from 37 species (20 genera) in the near-natural savannah in the Pama reserve to 19 ant species (nine genera) in the cotton fields with recent pesticide application.

Termite communities

The checklist of all termite species present under the different disturbance regimes is given in Table 3. Lowest numbers of species, genera, subfamilies, and functional groups were found in areas heavily impacted by humans. Fungus-growers dominated the termite fauna in all study sites. The highest variations between the habitats occurred in soil- and grass-feeding termites.

The four Zaï stages together hosted 33 termite species out of 11 genera and five subfamilies (Table 3). The number of termite species strongly decreased with increasing human impact from 25 species (13 genera) in the old Zaï forest to only one fungus-growing *Odontotermes* species in the most degraded stage. Except for the degraded site, all four functional groups were represented in the Zaï stages.

Together, the four habitats in the North Sudan region hosted 31 termite species out of 13 genera and five subfamilies (Table 3). The decreasing species richness was

obvious along the disturbance gradient: the number of termite species was highest in the reserve with restricted human impact (24 species, 11 genera) and drastically decreased with increasing human pressure to five species (three genera) in the cotton fields. Only the reserve and the short-term fallow hosted soil-feeding termites.

Comparisons among study sites

Incidence-based, randomized rarefaction or accumulation curves were used to graphically compare the discovery rate and the species richness of related habitats (Figs 4–5). Error bars correspond to one standard deviation of the mean after randomization. The colours in Figs 4–5 are identical to those used for the disturbance classes in Figs 6–7.

Ant communities

For ants collected between 2004 and 2008, rarefaction curves are presented in Fig. 4 for the habitats located a) in the sub-Sahel zone, and b) in the North Sudan region. For each region, we statistically compared the species richness at the level of the land-use type with the lowest sample number (degraded area, cotton fields). The number of ant species predicted at the common sampling effort (39 sampling units, in Figs 4a, b indicated by the dotted line) differed significantly between the sub-Saharan (Friedman, $N = 39$, $\chi^2(3) = 117$, $P < 0.001$) and the North Sudanese habitats (Friedman, $N = 39$, $\chi^2(3) = 117$, $P < 0.001$). A Wilcoxon sign-rank test (with Bonferroni correction) revealed statistical differences also between the 20-year-old forest and the millet field (Wilcoxon, $Z = -5.44$, $P < 0.001$, $R = 0.62$). In the sub-Sahel zone (Fig. 4a), the descend-

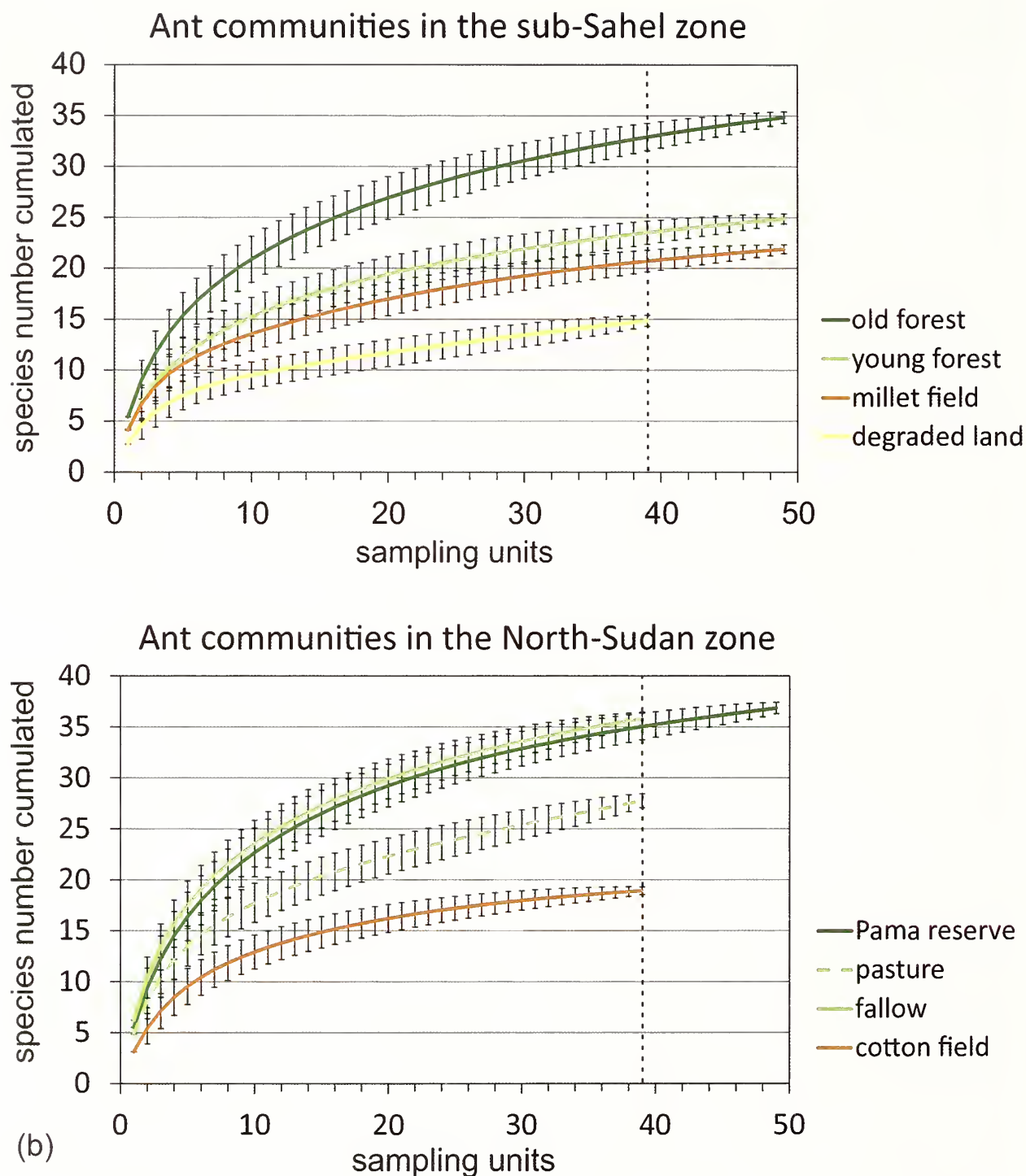


Fig. 4. Incidence-based rarefaction curves (including standard deviations) predicting the accumulation rate of ant species with increasing sampling effort in the habitats selected along the disturbance gradient in the a) sub-Sahel zone, and b) North Sudan region. Curves are predicted from richness values assessed along RAP transects; the rarefied number of 39 sampling units (the dotted line) was used to compare the related habitats. In the sub-Sahel zone, the expected richness and discovery rate of ant species decreased with decreasing restoration stage, and from the short-term fallow towards the cotton field in the North Sudan region. However, both the richness and the accumulation rate were almost identical in the fallow and the reserve (indicated by the overlapping error bars).

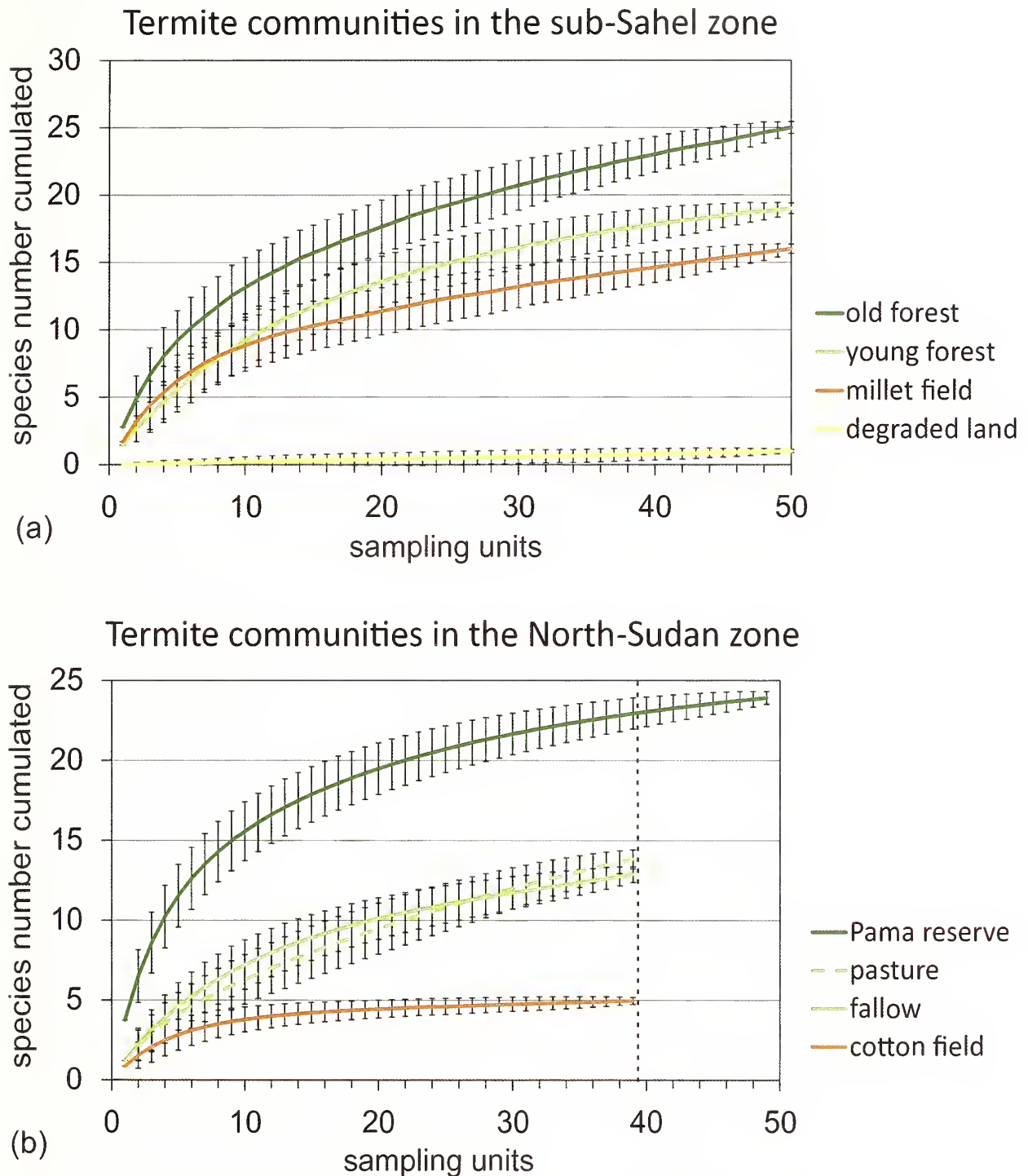


Fig. 5. Incidence-based, randomized accumulation (a) and rarefaction curves (b) indicating the accumulation rate of termite species with increasing sampling effort in the habitats selected along the disturbance gradient in the a) sub-Sahel zone, and b) North Sudan region. In the sub-Sahel zone, the richness and discovery rate of termite species decreased with decreasing restoration stage. In the North Sudan region, the richness predicted at the common sampling effort of 39 sampling units (the dotted line) decreased from the Pama reserve towards the cotton field, although the differences between the pasture and the fallow are not significant (indicated by the overlapping error bars).

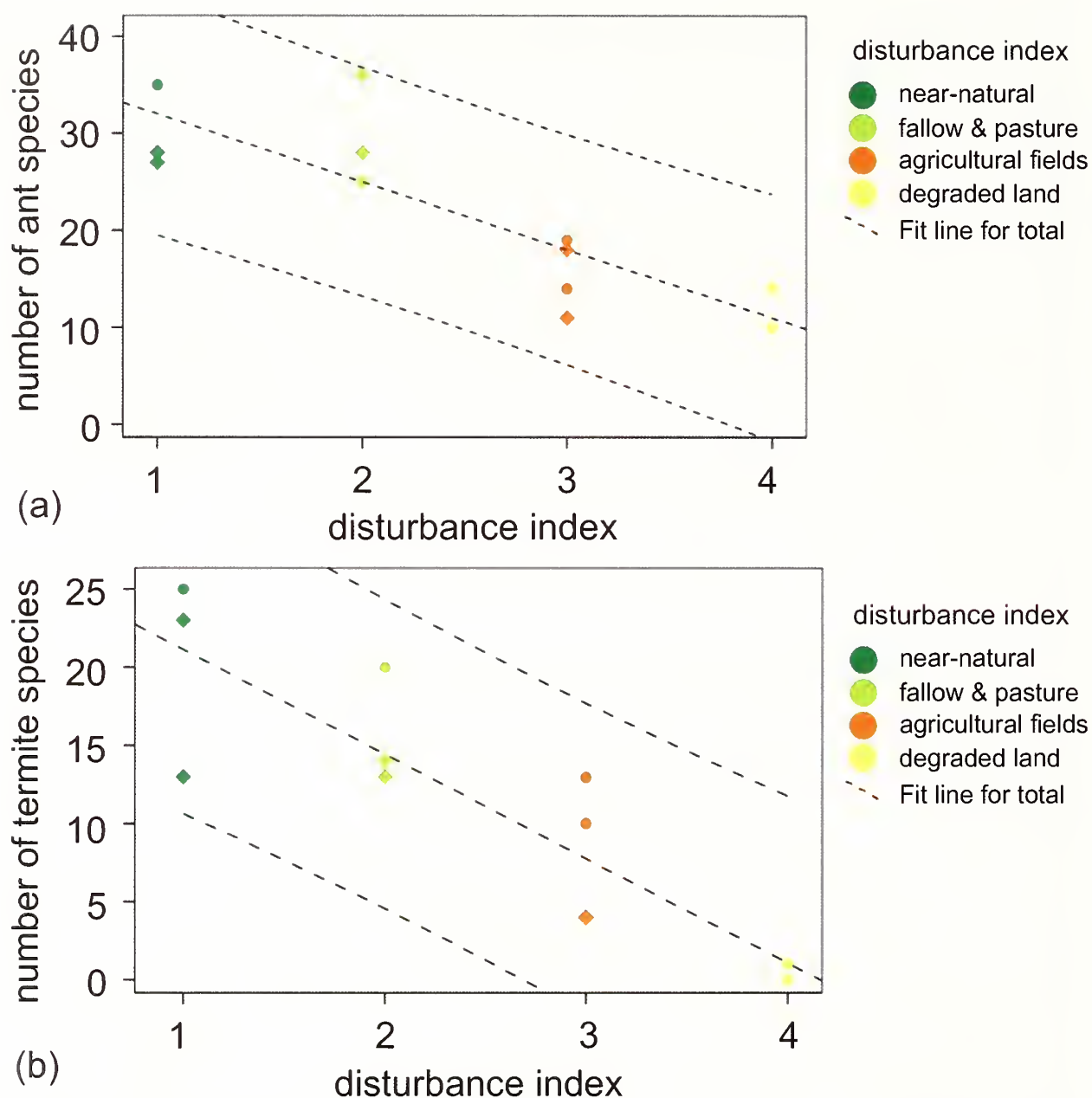


Fig. 6. Correlation between habitat disturbance and the number of a) ant species and b) termite species collected per site and plot in the sub-Sahel (circles) and the North Sudan region (rhombus). There was a significant negative relationship between the disturbance of a habitat and the number of ant species ($P < 0.05$, $F_{2,9} = 1.22$, $R^2 = 0.71$) and termite species ($P < 0.001$, $F_{2,9} = 37.26$, $R^2 = 0.89$).

ing order of all land-uses with regard to the expected number of ant species is old forest > young forest > millet fields > degraded soil, and short-term fallow > Pama reserve > pasture > cotton field in the North Sudan region (Fig. 4b). However, ant species richness did not differ significantly between the fallow and the reserve (Wilcoxon, $P > 0.025$ after Bonferroni correction) – both habitats also exhibited almost identical rates at which new species were added with the increasing sampling effort.

Termite communities

Quite similar to the trend observed for ants, the number of termite species observed in all transect sections differed significantly between the Zaï stages in the sub-Sahel zone (Friedman, $N = 50$, $\chi^2(3) = 141.94$, $P < 0.001$) (Fig. 5a) and between the four North Sudanese habitats (Friedman, $N = 39$, $\chi^2(3) = 106.68$, $P < 0.001$) (Fig. 5b). In the sub-Sahel zone, the descending order of the habitats with re-

gard to the number of termite species observed was old forest > young forest > millet field > barren land. At a low sampling effort, however, the discovery rate of termites in the millet field was higher than in the young forest (indicated by the crossing curves at sampling unit 9). In the North Sudan region, the number of species predicted at the common sampling effort decreased in the order: reserve > pasture > fallow > cotton field although the differences between the pasture and the fallow were not significant (Wilcoxon sign-rank test, $P > 0.025$ after Bonferroni correction). The rate at which termite species were added at a lower sampling effort was higher in the short-term fallow than in the pasture (please note the crossing curves at sampling unit 27).

All rarefaction and accumulation curves roughly approach an asymptote. Figs 4–5, therefore, indicate that we representatively characterised the termite and ant fauna, also proving that the spectrum of methods we used was appropriate.

Effect of land-use intensity on species richness

To analyse the correlation between species richness and habitat disturbance, each habitat type was assigned to one of four disturbance classes with 1 used for the near-natural habitats and 4 the degraded, barren land (please refer to the method-section).

Fig. 6 shows the number of ant (Fig. 6a) and termite (Fig. 6b) species collected in Burkina Faso as a function of the habitat disturbance. Each point comprises the number of species collected per study plot; the study region is indicated by the shape of the point with a rhombus used for the North-Sudanese sites and circles for the sub-Saharan ones.

A linear regression analysis was performed. The scatterplots (Figs 6a, b) suggest a strong negative correlation between species richness and habitat disturbance: as the land-use intensity increases, the species richness of termites ($P < 0.001$, $F_{2,9} = 37.26$) and ants ($P = 0.05$, $F_{2,9} = 11.22$) decreases.

For the ant species, richness R^2 is 0.71, i.e. only 29% of the variance in species richness could not be explained with this model. When the ants' species richness in a habitat was predicted, land-use intensity was found to be a significant predictor ($\beta = -0.86$, $P < 0.05$), whereas the study region was not ($\beta = -0.05$, $P > 0.05$). When the termites' species richness in a habitat was predicted, both land-use intensity ($\beta = -1.03$, $P < 0.001$) and study region ($\beta = -0.39$, $P < 0.05$) were found to be significant predictors. The overall model fit for termites is $R^2 = 0.89$, i.e. only 11% of the variance could not be explained with the model.

DISCUSSION

Combining both regions, 65 ant species (25 genera and nine subfamilies) and 42 termite species (13 genera and five subfamilies) were collected according to the combined RAP (Tables 2 and 3). Depending on the study site, between 40 and 50 transect sections (Figs 4–5) were sampled between 2004 and 2008. All accumulation and rarefaction curves in Figs 4–5 roughly approach an asymptote, therefore, indicating that we representatively characterized the termite and ant fauna. To our knowledge, these findings represent the first records for termites and ants in Burkina Faso.

Species richness along disturbance gradients. Termites and ants were highly sensitive to land-use intensification – extensively managed or degraded habitats hosted the lowest numbers of species, genera, subfamilies, and functional groups (Tables 2 and 3, Fig. 6). Similar findings were also reported from other regions: termite communities were consistently found to be less diverse in disturbed habitats (for example, see Davies et al. 1999; Donovan et al. 2007; Gathorne-Hardy et al. 2006; Vaessen et al. 2011), and crops and plantations hosted less species than nearby natural vegetation (see Black & Okwakol 1997 and references therein). Although direct comparisons are hampered due to differences in soil type, rainfall or the intensity of agricultural activity, a review of 10 studies revealed that ant species richness was nearly always lower in farmland environments than in naturally vegetated areas (Lobry de Bruyn 1999). Similarly in Côte d'Ivoire, the number of ant species decreased from relatively well conserved to the most extensively managed land-use types (Yéo et al. 2011).

Therefore, and since increasing land-use intensification progressively simplified the habitats' physical structure in our study sites (Table 1, Figs 2A–H), we did expect that the species richness of both taxa would decrease with increasing human impact. Very astonishing, however, was the extent to which their richness decreased in heavily impacted habitats. The termite fauna was especially impoverished. Unsustainable land-use and the reduction of vegetative cover affect termites and ants, for instance, by resulting in a loss of available feeding and nesting sites or by exposing them to greater physiological stress in the pedosphere (for example, see Agosti et al. 2000; Jones et al. 2003).

The enormous loss of taxonomic and functional diversity of the focal arthropods may have disastrous consequences for small-scale subsistence farmers, impeding a sustainable agricultural production. Hence, especially promising are the observations concerning a resilient agricultural production and the progressive restoration of an increasingly diverse flora and fauna (particularly termites and ants) on initially barren crusted soils with the Zai practice. To our knowledge, no other study has investigated

the recovery potential of termite and ant communities in fully degraded, crusted soils. The study of Gathorne-Hardy et al. (2002) in Southeast Asia revealed that an *Imperata cylindrica* grassland and a cassava field, both hosting a strongly reduced termite fauna, had the potential to recover when left fallow near a source area of primary forest for more than 50 years. Dibog et al. (1999) observed that tree-based agriculture in the Amazon had the potential to support the function of soil termite fauna even on land previously used as pasture.

To conclude, the present study provides a baseline for future monitoring studies in Burkina Faso and the comparison of termite and ant diversity between the different disturbance regimes. We present a combination of standard sampling methods (Fig. 3) that are easy to learn and effective to representatively, but rapidly, assess termites and ants in various (agro)ecosystems of semi-arid tropical regions (Figs 4–5). Since crop production will have to increase strongly to meet the growing food demand driven by the ongoing human population growth (Godfray et al. 2010), more techniques are needed to increase soil fertility and maintain the sustainability of agricultural production by harnessing ecosystem services of naturally occurring organisms. Given the crucial role of termites and ants in ecosystem functioning throughout the tropics and subtropics, special focus should be put on techniques that support or fasten the recovery of their communities in highly degraded lands. More studies are, therefore, needed that investigate the responses of termite and ant communities to habitat perturbations, the succession of their communities during habitat rehabilitation, and that clarify how the successions relate to the recovery of biodiversity and ecosystem processes.

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Böhme, W. (2014): Herpetology in Bonn. *Mertensiella* 21: 256 pp.

The impressive book reviews the history of herpetological research and herpetological collections in Bonn in unexpected details. It starts with the old Prussian university, which hosted the former natural history museum. This chapter also includes biographic sketches about important researchers, who worked in the field of herpetology and were based in Bonn, or worked with the Bonn collection. This includes e.g., well known persons like Georg August Goldfuss, Franz von Leydig, and Georg Jan. This chapter ends with a short summary about contemporary institutions involved in research about amphibians and reptiles, like the Federal Agency of Nature Conservation which is based in Bonn.

However, the most important chapters of the book are about the Zoological Museum Alexander Koenig (ZFMK) and its herpetological research. At this point I have to say that the book could be easily an auto-biography, because Wolfgang Böhme is by all means the person who is responsible for the international reputation of the ZFMK herpetological collection. However, it is very enjoyable that the person who has the best knowledge about this collection wrote about the history and the involved former researchers and recent students, instead about primarily himself. The part about the ZFMK collection starts with a historic sketch about the foundation of the herpetological department and its first curator, Karl F. Buchholz. It is followed by sketches about the succeeded curators, but most importantly by the history, including important researchers, of the four main collections which were donated to the ZFMK collection. This includes specimen donation from the University of Kiel and Heidelberg, as well as the Göttingen collection and the Paul Müller collection. This historic part is followed by a complete type catalogue of the ZFMK herpetological collection, a chapter about national and international herpetological symposia held at the ZFMK, and is rounded down by a chapter on herpetological teaching at the ZFMK, and its "scientific output".

Although the last type catalogue was published lately ago (BÖHME 2010), the type catalogue herein is more than just an update. It includes not only also detailed information also about secondary types, but also to specimens erroneously considered as types, and lost type specimens, which are mainly from the Göttingen collection. Moreover, many important comments are given to problematic specimens. Therefore, this type catalogue is not only the most current catalogue, but also the most detailed one of the ZFMK herpetology collection.

By several points this book is an important contribution to herpetology. It is the first detailed review of herpetological research in Bonn, also including other institutions than the ZFMK. It includes a detailed history about the ZFMK collection and the researchers, as well as students who are involved in the "evolution" of this collection, with a strong international reputation, and it includes the most updated type catalogue of primary and secondary types. All of this is written by the person who has not only an excellent knowledge about the ZFMK itself, but also the



best overview regarding herpetological research in Bonn. Under the authority of Wolfgang Böhme, the collection has grown from about 10.000 specimens to one the largest collections in Germany. Therefore it is hard to find any critical points or mistakes. There are some minor details in the type catalogue, e.g. that it could be mentioned that the recent name of *Lacerta stellio* is *Stellagama stellio*. Moreover I am very sure that, even that the book is published in 2014, the type catalogue was out of date by the time of its publication, largely due to ongoing research of its author.

Summarizing I can say that everybody who is interested in the history of the ZFMK collection, or in the history of German herpetological research, should have this book. It is full of details and historic herpetological knowledge, and it serves some enjoyable early photographs of important recent herpetologists like e.g., Frank Glaw, Ulrich Joger, Jörn Köhler, Andreas Schmitz, Miguel Vences, Thomas Wilms and Thomas Ziegler.

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Checklist of the Mammals of Iraq (Chordata: Mammalia)

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Abstract. A checklist of the mammals of Iraq including their current status and geographical distribution is provided. Data were collected from literature and combined with field observations obtained during 2013–2014. The checklist comprises 93 species of wild mammals occurring in Iraq and belonging to eight orders, 28 families, and 65 genera. The status and distribution of three Erinaceomorphs, three Soricomorphs, 20 Bats, 23 Carnivores, eight Artiodactyls, two Lagomorphs, 28 Rodents, and six Cetaceans are reported. The checklist includes 24 species evaluated by the International Union for the Conservation of Nature and Natural Resources: one was listed as Extinct, one as Critically Endangered, four as Endangered, eight as Vulnerable, seven as Near Threatened, and three as Data Deficient. One subspecies of carnivores (Smooth-coated Otter *Lutrogale perspicillata maxwelli*) and one rodent species (Long-tailed Nesokia *Nesokia bunnii*) endemic to Mesopotamian marshlands were highlighted as taxa with conservation priority to Iraq. We also focused on main threats to the most common wild mammals with special attention to impacts of illegal hunting and poaching.

Key words. Iraq, systematic checklist, vertebrates, wild mammals, endemics

الخلاصة

فيما يلي القائمة التصنيفية للبائن (الثدييات) البرية في العراق مع ذكر وضعها وانتشارها الجغرافي الراهن. تم جمع المعلومات من خلال المراجع التاريخية وبعض المشاهدات الحقلية التي أجريت خلال الفترة من 2013–2014. تشمل القائمة الحالية ثلاثة وتسعون نوعاً من البائن المتواجدة في العراق والتي تعود إلى ثمانية رتب وثمانية وعشرون عائلة وخمسة وستون جنساً. أن الوضع الحالي والانتشار الجغرافي لثلاثة أنواع من القناظر، ثلاثة أنواع من الزبائيات، عشرون نوعاً من مجنحات الأيدي (الخفافيش)، ثلاثة وعشرون نوعاً من الضواري، ثمانية أنواع من شفيعية الأغلاف، نوعان من الأرانب البرية، ثمانية وعشرون نوعاً من القوارض، وستة أنواع من البائن البحرية (الحيتان والدلافين) قد تم نشره ضمن القائمة الحالية. تضم القائمة أيضاً على أربعة وعشرون نوعاً من البائن في العراق قد تم تقييمه من قبل الاتحاد العالمي لصون الطبيعة والموارد الطبيعية كالتالي: نوع واحد منقرض من البرية، نوع واحد ذو حالة حرجية، أربعة أنواع تم تقييمها كأنواع مهددة بخطر الانقراض، ثمانية أنواع عرضة لخطر الانقراض، سبعة أنواع تحت وطأة (قريبة من) الانقراض، بينما يفتقر ثلاثة أنواع إلى المعلومات الكافية للتقييم. كما يمتلك العراق نوعاً من الضواري وهو القضاة (كلب الماء) ناعمة الفراء العراقية *Lutrogale perspicillata maxwelli* ونوعاً متميزاً من القوارض وهو الركين طويل الذيل *Nesokia bunnii* المستوطنان للأهوار بلاد ما بين النهرين وذوي أهمية صون قصوى للعراق. إضافة إلى ذلك قد تم إجراء تقييم عن أهم المهددات وحالة الصون للأنواع الشائعة خاصة فيما يتعلق بالنشاطات البشرية غير المرخصة كالأسر من البرية والصيد الجائر وتأثيرها على وضع البائن البرية في العراق.

INTRODUCTION

The territory of Iraq is comprised between latitudes 29° to 38° N and longitudes 39° to 49° E (a small area lies west of 39°) and spans over 437,072 km² (168,754 sq mi). It borders with Turkey to the north, Syria to the northwest, Iran to the east, Jordan to the west, Saudi Arabia to the south and southwest, and Kuwait to the south. Border with the latter is marked by a narrow section of coastline stretching for 58 km (36 mi) in the northern Arabian Gulf. The landscape includes high mountains in the north (Kurdistan), desert, arid lands, and sandy steppes in the western and south-western plateau (Al-Badiyah), and the Mesopotamian marshlands in the southern alluvial plain. This wide range of habitats awards Iraq with a noticeable biodiversity, the wild mammals being not an exception (Fig.1).

Since Hatt (1959) little was known about the mammals of Iraq. Most of the observations available to date for Iraq were due to Robert T. Hatt, indeed. In 1959, he published “The Mammals of Iraq”, where he included data collected on wild and domestic animals during surveys carried out between October 1952 and March 1953 under the auspices of the United States Educational Foundation of Iraq (“Fulbright Foundation”). Hatt’s report is considered the first checklist of the mammals of Iraq, as it includes not only author’s own findings but also both material and reports provided to him by Charles A. Reed and Lee Merriam Talbot. Charles A. Reed (School of Pharmacy, University of Illinois, USA) joined to an expedition to study the historical fauna of Iraq in 1954–1955. He was supported by a grant of the National Science Foundation (USA) and worked in collaboration with the Oriental Institute of the University of Chicago. Lee Merriam Talbot visited Iraq

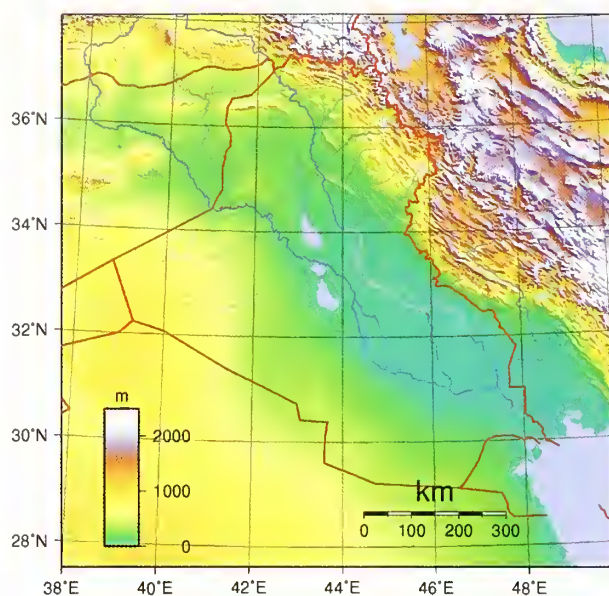


Fig. 1. Map showing the major landscapes in Iraq.

briefly in 1955 under the auspices of the International Union for the Conservation of Nature and Natural Resources (IUCN) to get insight into the status of a few threatened large mammals.

Another relevant contribution to the knowledge of the terrestrial mammals of Iraq was provided by David L. Harrison (co-author; deceased March 2015), who joined the British Royal Air Force in 1953 and carried out the major part of his national service in Iraq. Harrison reviewed Hatt's records and made further field observations especially by surveying the surroundings of Ramadi and Habbaniya in central Iraq (Anbar Province). His work was published in three volumes entitled "The Mammals of Arabia" (1964; 1968; 1972). Further updates were included in the second edition of his book that was published in 1991. In his books, Harrison exhaustively addressed the entire information available for the mammalian fauna of Iraq during the period 1953–1991.

In 1969, Nuri Mahdi and P.V. George prepared their checklist of the vertebrates of Iraq, which included wild and domesticated mammals. Mahdi & George (1969) listed 88 mammalian species according to the systematic arrangement of Ellerman & Morrison-Scott (1951). They included taxa that had been actually recorded in Iraq and those that were assumed to occur as well, citing previous literature records and reporting the catalogue of the specimens included in the collection of the Biological Research Centre in Baghdad (BRCB). However, Mahdi & George's checklist failed to provide detailed information on all the listed species (e.g., distribution range and/or collecting localities and dates).

The present checklist takes into account eight orders, 28 families, 65 genera and 93 species of mammals of Iraq including both their taxonomic status and geographical distribution (Table 1). Nomenclature adopted in this checklist follows third edition of Mammal Species of the World (Wilson & Reeder 2005) unless otherwise stated.

EXTINCT SPECIES

The historical record of the mammals of Iraq (Hatt 1959) included many species that are currently extinct. The Mesopotamian Lion (*Panthera leo persica*) was present along the Euphrates River in the early XIXth century. Last representatives of the species were killed at the time of the military actions of the British forces (1916–1918). Historical occurrence of the Tiger (*Panthera tigris*) in Iraq is documented by Kock (1990). The Indian One-horned Rhinoceros (*Rhinoceros unicornis*) is known only by a single lower tooth from the Paleolithic site of Barda Balka, and by later sculptural representations that likely referred to animals of Indian origin. Accurate depictions of Bison (*Bison bonasus*) resembled on cylinder seals and potteries were found in Mesopotamia (4000 to 2000 B.C.). The Siva's Giraffe (*Sivatherium giganteum*) inhabited Iraq during the Paleolithic and was present as late as 3500 B.C.. It is presumed that the Water Buffalo (*Bubalus bubalis*) was also native to Mesopotamia. In fact, the wild type was frequently portrayed until about 2100 B.C. before it went extinct. Teeth testifying the presence of the Elephant (*Elephas maximus*) in Iraq in the late Pleistocene are also known. Bones and representations of Wild Ox or Aurochs (*Bos primigenius*) are abundant in archeological sites from the Palaeolithic to the IXth century (B.C.). The Syrian Wild Ass "Onager" (*Equus hemionus hemippus*) was abundant in the plains of north-western Iraq, but since the middle of the XIXth century its number has dramatically decreased due to over-hunting. The last herd was reported near Jabal Sinjar in 1927 (Raswan 1935; Hatt 1959). A few bone fragments, teeth, and some reasonably accurate depictions of the Red Deer (*Cervus elaphus maral*) testify the early occurrence of this species in Iraq, although there is lack of evidence for its more recent presence. Nevertheless, the species still inhabits Turkey and Iran. A Beaver (*Castor fiber*) mandible was found in Palaeolithic deposits of Iraq as well as near the Khabur River in eastern Syria in 1837; the latter, however, was not reliably assessed and could be assigned also to an Otter (*Lutra* sp.) (Hatt 1959). As part of this work, we revised the taxonomic identification of the species that were misidentified or overlooked. Finally, we included the Arabian Oryx (*Oryx leucoryx*) in the checklist as it has occurred until recently in the southern desert of Iraq (Harrison 1968; Harrison and Bates 1991; Al-Sheikhly 2012c).

TAXONOMIC REMARKS

Erinaceomorpha

Early records of the European Hedgehog (*Erinaceus europaeus*) from Iraq can be referred now to the Southern White-breasted Hedgehog (*E. concolor*) (Harrison & Bates 1991).

Soricomorpha

Nader (1969) examined specimens of Bicolored White-toothed Shrew, which were assigned by Hatt (1959) to the Iranian subspecies (*Crocidura leucodon persica*), and re-assigned them to *C. russula*. A more recent investigation carried out by Hutterer & Harrison (1988) has provisionally allocated Hatt's (1959) specimens to the Lesser White-toothed Shrew (*C. suaveolens*).

Chiroptera

Kinnear (1916) reported the presence of "*Rhinopoma arabicum*" (= *R. arabicum*) in Iraq, a taxon formerly regarded as subspecies of Lesser Mouse-tailed Bat (*R. hardwickii*) (Ellerman & Morrison-Scott 1951, Simmons 2005). Presently, the name *arabicum* is applicable to the Levantine and Arabian populations of *R. cystops* (Berda et al. 2009). Khajuria (1988) described *R. hadithaensis* as a new bat species from the western Iraq; however, this taxon is now considered as junior synonym of *R. microphylum* (Kock et al. 2001). Both *Taphozous kachliensis babylonicus* and *Taphozous magnus* are presently regarded as synonym of the Naked-bellied Tomb Bat (*Taphozous nudiventris*) (Harrison & Bates 1991, Simmons 2005). As far as Kinnear's (1916) record of the Mediterranean Horseshoe Bat (*Rhinolophus euryale*) is concerned, Cheesman (1920) and Hatt (1959) found no confirmation for its occurrence in Iraq. Niazi (1967) reported the occurrence of *R. euryale* in two localities in Iraq. However, according to the cranial measurements, Harrison & Bates (1991) suggested that the specimens described by Niazi were in fact Mehely's Horseshoe Bats (*R. mehelyi*). Mahdi & George (1969) included *R. euryale* in their list without providing details (e.g., voucher specimens or sampling locality) on the collected material.

Rzebik-Kowalska et al. (1978) collected the first known specimens of Natterer's Bat (*Myotis nattereri*) in Iraq; nevertheless, these individuals were larger than the locally known forms and might represent a distinct taxon (Harrison & Bates 1991). Harrison (1956a) discovered Serotine Bat (*Eptesicus serotinus turcomanus*) in northern Iraq. However, this record was assigned later by Harrison & Bates (1991) to Anatolian Serotine [*E. bottae anatolicus* (= *E. anatolicus*)] (Juste et al. 2013). Another individual collected in Baghdad and initially identified as Northern Bat (*E. nilssoni nilssoni*) by Hatt (1959) was subsequently assigned to *E. bottae* (Harrison 1972; Harrison & Bates 1991). Hatt (1959) also reported the occurrence

of the Hingston's Serotine Bat (*E. sodalis hingstoni*), which was considered later on as synonym of *E. bottae* (Harrison & Bates 1991). Harrison (1964) considered the Sind Serotine Bat (*E. nasutus*) and Wall's Serotine Bat (*E. walli*) as synonymous. Records from Iraq of *E. walli* and its synonym, *Vespertilio matschiei pellucens*, are reported as *E. nasutus* (= *Rhyneptesicus nasutus*) by Harrison & Bates (1991). Similarly, previous records of the Cox's Pipistrel (*Pipistrellus coxi*) are now referred to Rüppell's Pipistrelle (*P. rueppellii*), while the Schreiber's Bat or Long-winged Bat (*Mimopterus schreibersi pulcher*) described by Harrison (1956) is considered to be synonym of *M. s. pallidus* (= *M. pallidus*) by Harrison & Bates (1991). Finally, Metaxas (1891) reported the occurrence of both Particolored (*Vespevtilio murinus*) and Long-eared (*Plecotus auritus*) Bat in Iraq, but Hatt (1959) could not confirm these records.

Carnivora

According to Lawrence (1956) both Iranian (*Canis lupus pallipes*) and Arabian (*C. l. arabs*) Wolf did occur in Iraq, where a zone of hybridization between the two subspecies is known in the western part of the country (Harrison & Bates 1991). Very recently, the Arabian Wolf was recorded in the extreme western Iraq by Al-Sheikhly (2012b). Al-Sheikhly (2012) recorded the Syrian Jackal (*Canis aureus syriacus*) for the first time in western Iraq. Similarly, the Indian Grey Mongoose (*Herpestes edwardsi*) was recently observed for the first time in northern Iraq. This record represents a large extension of the species range in Arabia (Al-Sheikhly & Mallon 2013).

The Red Fox (*Vulpes vulpes*) observed in the deserts of Iraq and assigned by Hatt (1959) to the Indian subspecies (*V. v. pusillus*) is now listed as Arabian Fox (*V. v. arabica*) according to Harrison & Bates (1991). Captured individuals and pictures taken by means of stealth camera traps referring to Rüppell's Sand Fox (*Vulpes rueppellii*) were published in the Al-Assad au Natural (newsletter of the 371st Sustainment Brigade of the Ohio Army National Guard, Al-Assad base, Anbar Province- N-SB). According to the morphological traits of the animals reported in Al-Assad au Natural newsletter, it seems much more likely that the reported Sand Foxes were in fact Arabian Red Foxes (*V. v. arabica*). However, *V. rueppellii* was reported once at Khan Al-Baghdadi in western Iraq by Al-Assad au Natural (2009).

Mahdi & George (1969) reported the likely occurrence of the Fennec Fox (*V. zerda*) in Iraq. Al-Robaac (1982) collected an individual near Jabal Sanam (c. 30 km south west of Basra, extreme southern Iraq). The same author also reported that an individual was captured alive near Jabal Hafit (United Arab Emirates) and kept at the Al-Ain Zoological Garden. Later on, Gasperetti et al. (1985) proved that the Jabal Hafit fox was in fact *V. rueppellii*.

The Middle East Badger (*Meles canescens*) was shown recently to represent a separate species distinguishable from its closest relative, the European Badger (*Meles meles*) by a combination of cranial and dental characters (Abramov & Puzachenko 2013).

The Smooth-coated Otter [*Lutrogale perspicillata* (the endemic subspecies: *L. p. maxwelli*)] was believed to be extinct in Iraq by the 1990s. However, during field surveys carried out in 2007–2012, Al-Sheikhly & Nader (2013) proved the occurrence of the species in the southern marshes.

Finally, whereas the endangered Persian Leopard (*Panthera pardus saxicolor*) has been recently recorded in many localities of northern Iraq (Kurdistan), there has been no recent sighting of the Asiatic Cheetah (*Acinonyx jubatus venaticus*) since Hatt's (1959) report; hence, the latter is considered as virtually extinct in Iraq.

Artiodactyla

Details about the Gazelles complex and their distribution in Iraq was reported by Al-Sheikhly (2012c). However, further investigation is required to update the distribution of both the Arabian Sand Gazelle (*Gazella subgutturosa marica*) and Persian Gazelle (*G. s. subgutturosa*) in Iraq.

Lagomorpha

With reference to the status of the Hare in Iraq, Hatt (1959) regarded *connori* as subspecies of the European Hare (*Lepus europaeus*). However, according to some genetic investigations Harrison & Bates (1991) considered the European and Cape Hare as closely related taxa, and regarded *connori* as subspecies of the Cape Hare (*Lepus capensis*). Sanborn (1940) tentatively identified hares collected in Baghdad and Camp Rashid as European Hare (*L. europaeus connori*), which is now regarded as synonym of *L. c. connori*. Hubbard (1955) reported the occurrence of *Lepus babylonicus* in Baghdad and Hilla, a taxon now considered as synonym of *L. capensis*. The Syrian subspecies of the Cape Hare (*L. c. syriacus*) was recently recorded (April 2012) c. 17 km to the north west of Rutba (Anbar Province) near the Iraqi-Syrian borders (Al-Sheikhly, in litt.).

Rodentia

Hatt (1959) included the Persian Squirrel (*Sciurus anomalus anomalus*) among the Iraqi rodents with comparatively deep red-coloured tails; nevertheless, these records are now considered as referable to the Caucasian Squirrel (*S. a. pallescens*) (Harrison 1956a; Harrison & Bates 1991).

Khajuria (1981) assigned two rats from Al-Qurna (Basra Province) to a new taxon under genus *Erythroneosokia*, but shown to be a distinctive species of *Nesokia*, Long-tailed *Nesokia* (*Nesokia bunnii*) by Al-Robaee & Felten (1990). However, later on Harrison & Bates (1991) sug-

gested that these individuals could provisionally be referred to as Short-tailed Bandicoot Rat (*Nesokia indica*).

The earlier records of the Wagner's Gerbil [*Gerbillus (Hendecapleura) dasyurus*] mentioned by Cabrera (1901), Cheesman (1920), and Hatt (1959) are now considered referable to Harrison's Gerbil [*G. (H.) mesopotamiae*] (Harrison & Bates 1991). Similarly, Hatt's (1959) records of the Turkish Jird (*Meriones blackleri blackleri*) are now assigned to the Tristram's Jird [*M. (M.) tristrami*] by Harrison & Bates (1991).

The presence of the Afghan Mole Vole (*Ellobius fuscocapillus*) in Iraq is uncertain as it does not occur today in the south Levant, but fossils document its former presence during Pleistocene, about 220,000–110,000 and 80,000–60,000 years ago (Tchernov 1992; 1994). Hatt (1959) suggested that Afghan Mole Vole might still be present in the mountains of Kurdistan. Some fossils found in a 25,000 years old deposit (Cave of Hazar Merd) as well as other remains from an older deposit (Shanidar Cave) were assigned by Bates (1930) to *E. fuscocapillus*. Baltazard & Seydian (1960) reported the presence of the species in the locality of Penjwin; however, Petter (1961) excluded such an occurrence. The Iraqi records of *E. fuscocapillus* are now considered referable to the Transcaucasian Mole Vole [*Ellobius (Afganomys) lutescens*]. Hatt's (1959) records of the Persian Vole (*Microtus irani*) regarded as Social Vole [*Microtus (Microtus) socialis*] (Harrison 1972; Harrison & Bates 1991). Harrison & Bates (1991) included *guentheri* and *irani* under Social Vole *M. socialis*. However, *M. irani* has been separated as distinct taxon (Kefelioğlu & Kryštufek 1999; Golenishchev et al. 2002; Kryštufek & Kefelioğlu 2002).

Cetacea

Most of Iraq marine mammals' records were provided by Al-Robaee (1969, 1970, 1974, 1975). However, further investigation is needed to reliably describe the status of this order in Iraq.

MATERIAL AND METHODS

Evidence for both occurrence and distribution of the Iraqi mammals were obtained from field observations carried out in 2013 and 2014, and combined with the following literature records (listed according to the year of publishing): Layard (1852); Metaxas (1891); Cabrera & Viaje Del Sr (1901); Wettstein (1913); Lydekker & Blaine (1914); Wigram & Wigram (1914); Kinnear (1916); Thomas (1919a, b); Cheesman (1920); Capper (1921); Pitman (1922); Cheesman (1923); Cheesman & Hinton (1923); Musil (1927); Corkill (1929); Bate (1930); Pocock (1930); Corkill (1930); Pocock (1934); Dollman & Burlace (1935); Pocock (1936, 1938); Heptner (1940);

Sanborn (1940); Pocock (1941,1946); Ellerman (1947, 1948); Drower (1949); Ellerman & Morrison-Scott (1951); Felid (1951, 1954); Page (1954); Thesiger (1954); Felid (1955); Hubbard (1955); Weber (1955); Harrison (1956a, b, c); Sanborn (1956); Hayman (1957); Maxwell (1957); Petter (1957); Hoogstraal & Kaiser (1958); Reed (1958); Bodenheimer (1959); Harrison (1959); Hatt (1959); Maxwell (1960); Baltazard & Seydian (1960); Petter (1961); Harrison (1964); Thesiger (1964); Al-Robaee (1966); Von Lehmann (1966); Groves & Harrison (1967); Mahdi (1967); Al-Robaee (1968); Harrison (1968); Al-Robaee (1969); Mahdi & George (1969); Nader (1969); Al-Robaee (1970); Nasher (1970); Felten (1971); Nader (1971); Nadler et al. (1971); Andera (1972); Harrison (1972); Al-Robaee (1974, 1975); Kadhimi (1975); Thalen (1975); Al-Robaee (1976); Niazi (1976); Al-Robaee (1977); Jawdat (1977); Kadhimi et al. (1977); Bhatnager & El-Azawi (1978); Nadachowski et al. (1978); Rzebik-Kowalska et al. (1978); Shamsuddin & Mohammad (1978); Young (1978); Darviche et al. (1979); Kadhimi (1979); Kadhimi et al. (1979); Nader (1979); Matskási (1980); Jawdat & Mahmoud (1981); Kadhimi (1981); Khajuria (1981); Al-Robaee (1982); Al-Shenawi et al. (1982); Kadhimi & Mustafa (1983); Nader & Kock (1983); Al-Khalili (1984); Gasperetti et al. (1985); Kadhimi & Wahid (1986); Kadhimi et al. (1986); Nader (1968 a; b); Groves (1988); Hutterer & Harrison (1988); Khajuria (1988); Kadhimi et al. (1989); Kock (1990); Al-Robaee & Felten (1990); Nadachowski et al. (1990); Nader & Kock (1990a); Harrison & Bates (1991); Kadhimi (1997, 1998); Kock et al. (2001); McLellan & Garshelis (2006); Haba (2009); Mallon & Kingswood (2001); Al-Sheikhly (2012b, c); Coşkuna et al. (2012); Omer et al. (2012); Raza et al. (2012); Abass (2013); Al-Sheikhly & Nader (2013); Al-Sheikhly & Mallon (2013); Haba (2013); Lahony et al. (2013); Mohammad et al. (2013); Raza (2013); Al-Sheikhly et al. (2014); Al-Sheikhly et al. (2015). We also relied our work on mammal collections resident to: Biological Research Centre, Baghdad, Iraq (BRCB); Bombay Natural History Society, Mumbai, India (BNHS); Field Museum of Natural History, Chicago, Illinois, USA (FMNH); Harrison Institute (formerly Harrison Zoological Museum), Sevenoaks, Kent, UK (HZM); Iraqi Natural History Research Centre and Museum, Baghdad, Iraq (BRCB); Museum National d'Histoire Naturelle, Paris, France (PM); collection of the University of Michigan, Michigan, USA (UMC); Natural History Museum, London, UK (BMNH); Hungarian Natural History Museum - Hungary (HNHM).

Recent records were derived from direct visual observations of live animals in the wild or in captivity, dead specimens (hunted or trapped), and investigation of study skins or mounted specimens, tracks, scats, field signs, calls and vocalizations. Reports and photographs from members of the Iraqi Hunters Association (IHA) as well as in-

terview with local people were also considered. In addition, Baghdad Zoological Garden (BZG) and local animal markets were visited. Photo-identification was carried out by means of an EOS 40D and EOS 1Ds Mark II Canon digital SLR camera bodies attached to a Canon EF 400 mm F5.6L USM telephoto lens and Bushnell IR remote camera traps. The identification of the individuals collected during this study was based on Harrison & Bates (1991) and Aulagnier et al. (2008). The orders, families, genera, species and subspecies were listed in the order they appear in the 3rd edition of Wilson & Reeder's (2005). During 2013–2014 several recent records (RR) were made and presented in the text as the following: a single record made in Anbar Province in 2013 (An-13); multiple records made in Basra Province in 2013 and 2014 (Ba-13; 14) and so on.

RESULTS

Systematic list of the species

Order Erinaceomorpha

Family Erinaceidae

Southern White-Breasted Hedgehog *Erinacens concolor* (Martin, 1838)

Subspecies: *E. c. concolor* (Martin, 1838).

Distribution: Mountains, forests, and grassy steppes of northern Iraq. Recorded from: Hais 10 km NW Ser Amadia (Harrison 1956a); Banaman (Hatt 1959).

RR: Bradost Mountain (Er-14).

Long-eared Hedgehog *Hemiechinus auritus* (Gmelin, 1770)

Subspecies: *H. a. calligoni* (Satunin, 1901).

Distribution: Arid steppes, marshes, and riparians along the Tigris and Euphrates Rivers. Recorded from: Amara and Basra (Cheesman 1920); Hit, Al-Falluja, and near Samarra (Pitman 1922); Baghdad (Sanborn 1940; Hubbard 1955; Weber 1955); Mansuriya al Shatt (Hatt 1959; Nader 1968b; Martin & Nader 1975; Bhatnager & El-Azawi 1978; Shenawi et al. 1982); Chebaeish (Haba 2009); Jabal Makhool, Al'Alam, Hussaiba, and 3 km from Al-Qa-eem (Al-Sheikhly 2012); Hammar Marsh (Abass 2013).

RR: Jadriyah and Umm Al-Khanazeer Island, Yarmook, and Dor'ah (B-13); Hammar Marsh (Ba-14).

Desert Hedgehog *Paraechinus aethiopicus* (Ehrenberg, 1832)

Subspecies: *P. a. indlowi* (Thomas, 1919).

Distribution: Arid deserts and steppes of central and southern Iraq. Recorded from: Qasr al Helqum (Harrison 1959), 40 km E Rutba (Nadachowski et al. 1990), Hadithah and

Baghdad (Hatt 1959), Hit (type locality of *P. a. ludlowi*) and Hamam Al-Alil (Bhatnager & El-Azawi 1978).
RR: Rutba (An-2013).

Order Soricomorpha

Family Soricidae

Asian House Shrew *Smiscus murinus* (Linnaeus, 1766)

Subspecies: No named subspecies; Iraq population likely originate from north India.

Distribution: Introduced to extreme southern Iraq. Recorded from: Al-Qurna (Cheesman 1920); Basra (Hatt 1959); Chebaeish (Haba 2009); specimens collected in Fao are resident to the BMNH collection; Hammar Marsh (Abass 2013).

RR: Al-Qurna (Ba-13); Hammar Marsh (Ba-14).

Etruscan Shrew *Smiscus etruscus* (Savi, 1822)

Subspecies: *S. e. etruscus* (Savi, 1822).

Distribution: Bushland, cultivated fields, and marshes of southern and central Iraq. Recorded from: Basra and Amara (Cheesman 1920); Al-Falluja (Pitman 1922); Kut al Imarra (Hatt 1959); Habbaniya and the eastern bank of the Euphrates River (Harrison 1959; Harrison & Bates 1991); Hammar Marsh (Abass 2013).

Lesser White-toothed Shrew *Crocidura suaveolens* (Pallas, 1811)

Subspecies: Likely *C. s. portali* (Thomas, 1920) subspecies, with individual variation in the colour of pelage. Distribution: Mountains and steppes of northern Iraq. Recorded from: Bebaidi and Sarsank (Harrison 1956a; Hatt 1959); specimens from Cora and Almawan originally listed by Hatt (1959) as Bicolored White-toothed Shrew (*C. leucodon persica*), which was referred later to this species by Hutterer & Harrison (1988); the vicinity of Mousel (Andera 1972; Hutterer & Harrison 1988).

RR: Safen Mountain (Er-14).

Order Chiroptera

Family Rhinopomatidae

Lesser Mouse-tailed Bat *Rhinopoma hardwickii* (Gray, 1831)

Subspecies: *R. h. arabium* (Thomas, 1913).

Distribution: Apparently rare, restricted to the caverns in the arid steppes of western and central Iraq. Recorded from: 19 km E Hilla by Sanborn (1956); near Haditha (Hatt 1959; Nader 1971). A colony of 83 individuals were found roosting in a small cave at Sheikh Hadid sink hole near Haditha (Al-Sheikhly 2012).

Greater Mouse-tailed Bat *Rhinopoma microphyllum* (Brünnich, 1782)

Distribution: Uncertain. Recorded by Khajuria (1988) from Haditha in western Iraq as a distinct species (*Rhinopoma hadithaensis*), but regarded as a junior synonym of the Greater Mouse-tailed Bat (*R. microphyllum*) by Kock et al. (2001).

Family Emballonuridae

Naked-rumped Tomb Bat *Taphozous (Liponycteris) undiventris* (Cretzschmar, 1830)

Subspecies: *T. n. magnus* (Wettstein, 1913).

Distribution: Widespread, mainly along the Tigris and Euphrates Rivers. Recorded from: banks of Euphrates River (Kinnear 1916); Amara, Shaiba, Ctesiphon, and Basra (Cheesman 1920); Baghdad and Diltawa (Sanborn 1940); Ctesiphon arch (Weber 1955); between Habbaniya and Ar Ramadi, Habbaniya, and at Shaiba (Harrison 1956b); Aqqar-Quf, Baghdad, Fao, and Najaf (Harrison 1964); recorded also by Al-Robaee (1968), Shamsuddin & Mohammad (1978), Nadachowski et al. (1978), Al-Shenawi et al. (1982) and Haba (2009).

RR: Large colonies roosting in cracks of old buildings at Chebaeish (Th-14).

Family Rhinolophidae (Horseshoe bats)

Greater Horseshoe Bat *Rhinolophus ferrumequinum* (Schreber, 1774)

Subspecies: *R. f. irani* (Cheesman, 1921), with distinctive pale pelage.

Distribution: Limestone caverns and suitable retreats of northern and central Iraq. According to Hatt (1959) the species was reported to occur in Iraq only by Metaxas (1891) and Kinnear (1916). Recorded from: 130 km W Ramadi (Niazi 1976); Salahadin and Erbil Liwa (Nader & Kock 1983); a single specimen from Tang-i-dorg in Duhok is kept in the collection of the BMNH (Harrison 1964). Al-Robaee (1976) has tentatively identified some specimens from Mousel (Harrison & Bates 1991).

Lesser Horseshoe Bat *Rhinolophus hipposideros* (Bechstein, 1800)

Subspecies: *R. h. midas* (Anderson, 1905).

Distribution: Three specimens from Baghdad were reported by Cheesman (1920); this represents the only record for Iraq (Hatt 1959; Harrison & Bates 1991).

Mediterranean Horseshoe Bat *Rhinolophus euryale* (Blasius, 1853)

Subspecies: The Iraqi population can not be assigned to any named subspecies.

Distribution: Previous data of the species (Niazi 1976) represents *R. mehelyi* (see remarks below). The only definite record is from Bjil village, Akre District in northern Iraq (Al-Sheikhly et al. 2015).

Mehely's Horseshoe Bat *Rhinolophus mehelyi* (Matschie, 1901)

Subspecies: *R. m. mehelyi* (Matschie, 1901).

Distribution: Caves of arid areas in central and western Iraq. Niazi (1967) reported the occurrence of the Mediterranean Horseshoe Bat (*R. euryale*) in two localities; however, the species was proved to be in fact *R. mehelyi* (Harrison & Bates 1991, Al-Sheikhly et al. 2015). Recorded from: 43 km SW Ash-Shinaffya and 130 km W Ramadi; specimens collected in Al-Alfasia Cave (8 km S Haditha) are resident to the BMNH (Harrison & Bates 1991). Specimens collected in El Hashfe and Hadhita areas of Iraq (Matskási 1980) are kept in the collection of HNHM and those of collected in Bjil village, Akre District in northern Iraq will be deposited in BRCB.

RR: Three individuals were found roosting in a tunnel near Mawat (Su-14).

Family: Hipposideridae

Geoffroy's Trident Leaf-nosed Bat *Asellia trideus* (E. Geoffroy, 1813)

Subspecies: *A. t. murraiana* (Anderson, 1881).

Distribution: Common in deserts and arid steppes and wadis of central Iraq. Recorded from: Mousel (Wettstein 1913); Al-Falluja and "Lake" Aqar Quf (Cheesman 1920); Baghdad (Sanborn 1940; Hubbard 1955); Al Qa-ecm near the Syrian border (Weber 1955); between Ar Ramadi and Habbaniya and from Uqhaidhir (Harrison 1956); Mustansiriyah in Baghdad (Hatt 1959); recorded at many localities by Al-Robaee (1966), Shamsuddin & Mohammad (1978), and Nadachowski et al. (1990); at Sheikh Hadid sink hole near Haditha by Al-Sheikhly (2012).

Family: Molossidae

European Free-tailed Bat *Tadarida teniotis* (Rafinesque, 1814)

Subspecies: *T. t. rueppelli* (Temminck, 1826), with pale grey pelage colour.

Distribution: Uncommon, confined to the rocky terrain and crevices in western Iraq. Recorded from: Between Ar Ramadi and Habbaniya (Harrison 1956b; Harrison & Bates 1991).

Family: Vespertilionidae

Lesser Mouse-eared Myotis *Myotis blythii* (Tomes, 1857)

Subspecies: *M. b. omari* (Thomas, 1906).

Distribution: Confined to the caverns of northern mountains. Recorded from: Hazar Mard caves (Bate 1930; Hatt 1959); Diyana and near Baradust (Sanborn 1940; Harrison & Bates 1991).

Long-fingered Myotis *Myotis capacciuui* (Bonaparte, 1837)

Subspecies: *M. c. bureschi* (Heinrich, 1936).

Distribution: Uncertain; a male individual reported from

the ruined city of Kish; this is the only confirmed occurrence (Sanborn 1956; Hatt 1959; Harrison 1964; Harrison & Bates 1991).

Geoffroy's Myotis *Myotis emarginatus* (E. Geoffroy, 1806)

Subspecies: As no voucher specimens exist, the Iraqi population can not be assigned to any named subspecies.

Distribution: Niazi (1976: 172) reported the occurrence of this species in the mid-west part of Iraq but no exact locality or any detailed description was given. Two individuals were observed and photographed in Bjil village (Akre District, northern Iraq): this represents the only record for Iraq (Al-Sheikhly et al. 2015).

Natterer's Myotis *Myotis nattereri* (Kuhl, 1817)

Subspecies: Iraqi individuals investigated by Rzebik-Kowalska et al. (1978) were clearly smaller than the geographically closest and related taxon *M. nattereri araxensis* (= *Myotis schaubi*) but differed in certain cranio-dental traits from the other subspecies of *M. nattereri*. These individuals could be representative of a distinct taxon.

Distribution: Confined to the rocky caverns of the mountains of northern Iraq. Recorded from Gali Ali Beg, which is the only confirmed occurrence (Rzebik-Kowalska et al. 1978; Harrison & Bates 1991).

Botta's Serotine *Eptesicus bottae* (Peters, 1869)

Subspecies: *E. b. hingstoni* (Thomas, 1919), restricted to central and southern Iraq;

Distribution: Widespread. Recorded from: Basra, Baghdad, Nasiriyah, Karbal'a (Hatt 1959); Habbaniya (Harrison 1956b); Ramadi and Sulaymaniyah (Felten 1971); 35 km N An-Najaf, Al-Mahmudiya, Baqubah, and Al-Khalis (Nader & Kock 1990a).

Anatolian Serotine *Eptesicus anatolicus* (Felten, 1971)

The Anatolian Serotine, formerly regarded as subspecies of *E. bottae* has recently been elevated to the rank of species on the basis of combined evidences derived from cranial morphology, molecular DNA markers, and echolocation characteristics (Juste et al. 2013).

Distribution: Confined to the mountains and foothills of central and northern Iraq. Recorded from: Ser Amadia and Kani Mase (Harrison 1956a; Harrison & Bates 1991); Al-Alam (Al-Sheikhly 2012).

Sind Serotine *Rhyneptesicus nasutus* (Dobson, 1877)

Subspecies: *R. n. pellucens* (Thomas, 1906). *Rhyneptesicus* was re-elevated as a separate genus by Juste et al. (2013) on craniodental and phylogenetic grounds.

Distribution: Inhabits ruins and old buildings of central and southern Iraq. Recorded from: Zubeir and Shaiba as *Eptesicus n. pellucens* (Harrison 1964); Basra and



Fig. 2. Wolf hunting in Iraq. Photo © Hameed A. Al-Habash/ Iraqi Hunting Association.

Nasiriya (Sanborn 1940); Qalat Salih and Al Miqdadiyah (Nader 1971; Harrison & Bates 1991).

Kuhl's Pipistrelle *Pipistrellus (Pipistrellus) kuhlii* (Kuhl, 1817)

Subspecies: *P. k. ikhwanius* (Cheesman & Hinton, 1924), with pale desert pelage.

Distribution: Abundant and ubiquitous. Recorded from: Karbala, Baghdad, Mousel, Qalat Sharqat, Mejjadin, and Bahrka (Wettstein 1913); Amara, Baghdad, and Sheikh Saad (Cheesman 1920); Baghdad, Amara marshes, Shaikh Falih as Sailhud's camp, Al Halfayah, Balad, Sinjar, Badra, Diltawa, An Nasiriya, Karbala, and Rustamiyah Farm near Baghdad (Sanborn 1940); Baghdad, Al Qa-cem, the pipeline station T-1 and in Dhibban near Habbaniya (Weber 1955); Shaiba, Ramadi marshes, south of Amiriya, Ramadi-Habbaniya, Basra, Al Falluja, and Uqhaidhir (Harrison 1956b); Baghdad (Hatt 1959); Specimens from Fao, Kut as Sayyid, Basra, Khaniqin, Wadia south of Majar al Kabir of Amara, and from Ain Zalah 45 km S Mousel resident to the collection of the BMNH (Harrison 1964); recorded also by Shamsuddin & Mohammad (1978) and Al-Shenawi et al. (1982).

RR: Ramadi (An-13); Al-Adhamiyah; Jadriyah; Al-Yamook (B-13); Garimat Ali and Hammar Marsh (Ba-14).

Rüppell's Pipistrelle *Vansonia rueppellii* (Fischer, 1829) Subspecies: *V. r. coxi* (Thomas, 1919), with sandy-buff dorsal pelage. *Vansonia* was elevated to genus level by Koubínová et al. (2013) based on genetic data.

Distribution: Uncommon, inhabits settlements and ruins of central and southern Iraq. Recorded from: Al-Adhamiyah (Nader 1971); Basra and at Beit Sheikh Mahommad at the marshes of Chahala in Amara: these specimens are resident to BMNH collection (Cheesman 1920; Hatt 1959; Harrison 1964); Agergoof (Harrison & Bates 1991).

Hemprich's Desert Bat *Otonycteris hemprichii* (Peters, 1859)

Subspecies: *O. h. petersi* (Anderson & de Winton, 1902), in the eastern Euphrates basin and in central and southern Iraq; *O. h. jin* (Cheesman & Hinton, 1924), confined to the desert habitat of both extreme western and southwestern Iraq.

Distribution: Local, confined to arid steppes and rocky deserts of central and southern Iraq. Recorded from: Fao (Kinneir 1916) as well as by Ellerman & Morrison-Scott (1951), who listed the taxon as *O. petersi*, probably a synonym of *hemprichii* (Hatt 1959); Chamchamal-Jarmo valley in Kurkuk Liwa (Nader & Kock 1983; Harrison & Bates 1991); Al-Cidr and Himreen foothills (Al-Sheikhly 2012).

Family: Miniopteridae

Pallid Long-fingered Bat *Miniopterus pallidus* (Thomas, 1907)

Recorded as *Miniopterus schreibersii* (Kuhl, 1817) by Hatt (1959) and Harrison & Bates (1991). Mitochondrial and nuclear DNA studies corroborated by slight variations in size, wing shape, and echolocation call parameters suggested that *M. pallidus* should be considered as full species (Furman et al. 2010a, b).

Distribution: Uncertain, confined to the mountain caves of the extreme northern Iraq. Reported from: Ser Amadia (type locality of *M. p. pulcher*: Harrison 1956), the only record for Iraq (Harrison 1964; Harrison & Bates 1991).

Order Carnivora

Family: Canidae

Golden Jackal *Canis aureus* (Linnaeus, 1758)

Subspecies: *C. a. aureus* (Linnaeus, 1758), along the Tigris and Euphrates Rivers; *C. a. syriacus* (Hemprich & Ehrenberg, 1833), restricted to the desert and arid lands of the extreme western Iraq, yet probably present also in northern Iraq.

Distribution: Abundant along the river riparians, cultivated land, marshes, mountains and arid lands. *Canis a. aureus* recorded from: Babylon (Jebb 1908); Sheik Saad (Cheesman 1920); Jezira, c. 40 km W Mousel (Bodenheimer 1959); Habbaniya, Al Falluja and Samarra (Harrison 1959); Basra, Diyala and Hilla (Hatt 1959); the marshes near Majar (Thesiger 1964); Chebaeish (Haba 2009); Hammar Marsh (Abass 2013); Hawraman Mountain (Lahony et al. 2013). Specimens collected in Legait, Shahraban, Baghdad, Amara, near Kut, Shaiba, Fao and Saqlawiya are included in the collection of the BMNH (Harrison & Bates 1991). *Canis a. syriacus* recorded from: Rutba and Hussaiba (Al-Sheikhly 2012).

RR: *Canis a. aureus*, abundant in Al-Alam (Sa-13); Anah; Hit (An-13); Mashab and Hammar Marsh (Ba-14).

Gray Wolf *Canis lupus* (Linnaeus, 1758)

Subspecies: *C. l. pallipes* (Sykes, 1831), confined to the northern mountains and on eastern bank of the Euphrates River; *C. l. arabs* (Pocock, 1934), restricted to the arid steppes and desert of western and south-western Iraq.

Distribution: Widespread, *Canis l. pallipes* recorded from: Al-Shaiba and At Tanumah (Cheesman 1920); Ur (Pocock 1935); Rawanduz, Diyala, Sulaymaniyah, and Khaniqin (Sanborn 1940); Sinjar, Karadagh and umm al-Kahab Wells (Felid 1954); Erbil Liwa, near Jarmo, east Kurkuk Liwa, Lake Habbaniya and near Haditha (Hatt 1959); Jazira, c. 40 km W Mousel (Bodenheimer 1959); near Majar (Thesiger 1964); Central and Hammar Marsh (Haba 2009); Makhmore, Jabal Himreen, Jabal Makhool, and Wadi Al-Tharthar (Al-Sheikhly 2012); Hammar Marsh

(Abass 2013). *Canis l. arabs* recorded from: Rutba (Al-Sheikhly 2012b).

RR: *Canis l. pallipes*, Jabal Himreen (Di- 13; 14) (Fig.2).

Red Fox *Vulpes vulpes* (Linnaeus, 1758)

Subspecies: *V. v. arabica* (Thomas, 1902), around marshes, deserts, and arid steppes of central and southern Iraq; *Vulpes v. flavescens* (Gray, 1843), restricted to the foothills and mountains of northern Iraq.

Distribution: Widespread. *Vulpes v. arabica*, Recorded from: Qalat Luqait, Shatt al Adhaim, and Basra (Cheesman 1920); Hilla, Baghdad, and Baquba (Hatt 1959); Saqlawiya, Tikrit, Fort Ukhaider, Haur al Hasa, Falluja, and Tar al Hazar north west of Iraq (Harrison 1968). Specimens collected in Baghdad, Falluja, and Ctesiphon are included in BMNH collection (Harrison & Bates 1991); Hammar Marsh (Abass 2013); Hawraman Mountain (Lahony et al. 2013). *Vulpes v. flavescens* recorded from: Kurkuk, Rawanduz and Jarmo (Hatt 1959); near Amadia (Harrison 1959), Himreen foothills (Al-Sheikhly 2012). RR: *Vulpes v. arabica* recorded from Jadriyah and Yarmook districts (Ba-13); Hila and Dalmaj (Qa-14). *Vulpes v. flavescens* recorded from: Ramadi (An-13); Jabal Himreen (Sa-13).

Rüppell's Fox *Vulpes rueppellii* (Schinz, 1825)

Subspecies: *V. r. sabaia* (Pocock, 1934).

Distribution: Restricted to the arid steppes and desert of western and south-western Iraq. Recorded from: Haditha (Hatt 1959); Khan Al-Baghdadi (N-SB 2008); Massad Al-Rutba, Hussaiba, Ga'ara, Wadi Horan (10 km E Hadithah), Nikheab, and Khan Al-Baghdadi (Al-Sheikhly 2012).

RR: c. 30 km south of Rahaliya – Karbal'a desert (An-14) (Fig. 3).



Fig. 3. Adult male Rüppell's Fox *Vulpes rueppellii*, a carnivore confined to the desert habitat in western Iraq. Photo © Omar F. Al-Sheikhly 2014.

Fennec Fox *Vulpes zerda* (Zimmermann, 1780)

Subspecies: *V. z. zerda* (Zimmermann, 1780).

Distribution: Uncertain. Mahdi & George (1969) reported the likely occurrence of this species in Iraq. Al-Robaee (1982) collected an individual near Jabal Sanam SW of Basra, extreme southern Iraq.

Family: Ursidae

Brown Bear *Ursus arctos* (Linnaeus, 1758)

Subspecies: *U. a. syriacus* (Hemprich & Ehrenberg, 1828).

While bears in northern Iraq show brown-greyish pelage those inhabiting the district of Jilu are known for their pale fur. Nevertheless, individual variation and/or seasonal change in the pelage colour may occur.

Distribution: Confined to the mountains of extreme northern Iraq. Recorded from: Iraqi-Turkish frontier region (Wigram & Wigram 1914); Bradost Mountain north of Erbil Liwa, east of Sulaymaniyah (Hatt 1959); north east of Kurkuk (McLellan & Garshelis 2006); QaraDaq (Raza 2013).

RR: An adult bear was killed by locals nearby Duhok (Du-13); a specimen from the Zagros Mountain is included in the collection of the BRCB; two adult males collected in Haji Omran are presently kept at BZG.

Family: Mustelidae

Beech Marten *Martes foina* (Erxleben, 1777)

Subspecies: *M. f. syriaca* (Nehring, 1902).

Distribution: Confined to the mountains of northern Iraq. Recorded from: Iraq-Iran border (Cheesman 1920); Rawanduz (Sanborn 1940); Bradost Mountain (Field 1955); Narwa (Harrison 1956a); Hawraman Mountain (Lahony et al. 2013).

Marbled Polecat *Vormela peregusna* (Güldenstädt, 1770)

Subspecies: *V. p. syriaca* (Pocock, 1936), with individual variations in pelage color and pattern.

Distribution: Restricted to the high grounds of Mousel. Recorded from: c. 64 km S Mousel (Pocock 1936); Mousel (Hatt 1959); 45 km N Mousel (Allouse 1954; Harrison 1968; Harrison & Bates 1991); Hawraman Mountain (Lahony et al. 2013).

Least Weasel *Mustela nivalis* (Linnaeus, 1766)

Subspecies: Probably *M. n. boccamela* (Bechstein, 1800).

Distribution: Confined to the mountains of northern Iraq. Hatt (1959) did not find any definitive occurrence of the species, but he received hunters' reports where the presence of Weasel-like animals at Erbil Liwa (Zagros Mountain) was recorded. Confirmed record from Shirin Mountain in Barzan area (Raza 2013); Hawraman Mountain (Lahony et al. 2013).

Middle East Badger *Meles canescens* (Blanford, 1875)

Distribution: Confined to the mountains of northern Iraq,

with local distribution in central Iraq. Recorded from: Qali Ali Beg (Sanborn 1940); Baghdad (Hatt 1959); 20 km N Shaqlawa (Smielowski 1978); Hawraman Mountain (Lahony et al. 2013).

RR: Barzan Area (Er-14); Chami-reazan area (Su-14).

Honey Badger *Mellivora capensis* (Schreber, 1776)

Subspecies: *M. c. wilsoni* (Cheesman, 1920).

Distribution: Widespread in the desert and arid steppes of central and southern Iraq. Recorded from: Baksai (Cheesman 1920); An Nuhaidam (Harrison 1959); T1 station and Rawa (Hatt 1959); Abu Khasib (Anon 1966); Hammar Marsh (Abass 2013). Specimens from Fuluja are included in the collection of the BMNH (Harrison & Bates 1991).

RR: Ga'ara and Massad Al-Rutba (An-13); Nugratt Al-Salman (Mu-14).

European Otter *Lutra lutra* (Linnaeus, 1758)

Subspecies: *L. l. seistanica* (Birula, 1912).

Distribution: Lakes, streams, tributaries, and marshes of Tigris and Euphrates Rivers. Recorded from: Amara (Cheesman 1920); Qalat Salih (Sanborn 1940); Baghdad and Hindiya (Hatt 1959); Central marshes, vicinity of Al-Maimona, Musharah River, Tarmiya, Al-Alam, Samarra Lake, Himreen, Khan Al-Baghdadi, Haditha, Derbendikhan, Dukan, Little Zab, Barzan and TaqTaq (Al-Sheikhly & Nader 2013); recorded also in Mashab in eastern Hammar Marsh by Abass (2013). Specimens from Abusakhair (South of Hor Al-Hammar Marsh) are included in the collection of the BMNH (Harrison & Bates 1991). Recent records from Mashab River in eastern Hammar Marsh (Al-Sheikhly et al. 2014).

RR: Mashab and Salal River (Ba-14); Taq Taq (Er-14).

Smooth-coated Otter *Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826)

Subspecies: *L. p. maxwelli* (Hayman, 1956).

Distribution: Confined to the dense reed beds of the southern marshes; one record from northern Iraq (Kurdistan). Recorded from: Abusakhair and Azair (Hayman 1956; Maxwell 1957, 1960); Azair by (Hatt 1959); TaqTaq (Omer et al. 2012); Fao-Rass Al-Beisha, Abu Al-Khasib and Umm Al Rassas, Abu Ajaj-Hor Al-Hammar, Umm Al-Na'aj lake-Hawizeh, and TaqTaq (Al-Sheikhly & Nader 2013; Al-Sheikhly et al. 2014).

Family: Herpestidae

Small Asian Mongoose *Herpestes javanicus* (E. Geoffroy Saint-Hilaire, 1818)

Subspecies: *H. a. pallipes* (Blyth, 1845).

Distribution: Widespread along the Tigris and Euphrates Rivers. Recorded from: Basra (Cheesman 1920); Amara (Pitman 1922); Baghdad (Sanborn 1940); Hilla and Mousel (Hatt 1959); Habbaniya (Harrison 1959); Zeban,

c. 32 km from Falluja (Harrison 1968); Chebacish (Haba 2009); many localities Iraq (Al-Sheikhly & Mallon 2013); Al-Hammar Marsh (Abass 2013).

RR: Recorded from many sites in Al-Hammar Marsh (Ba-14); Chebacish (Th-14); Hawizeh (Ma-14).

Indian Grey Mongoose *Herpestes edwardsi* (E. Geoffroy Saint-Hilaire, 1818)

Subspecies: *H. e. ferrugineus* (Blanford, 1874)

Distribution: Local, in the rocky highlands of northern and central Iraq; however, it may be found in southern Iraq as well. Recorded from: Qashqulai and near Al-Alam (Al-Sheikhly & Mallon 2013).

RR: Near TaqTaqa (Er-14).

Family: Hyaenidae

Striped Hyena *Hyaena hyaena* (Linnaeus, 1758)

Subspecies: *H. h. syriaca* (Matschie, 1900). Pocock (1934) suggested that *H. h. syriaca* may be synonym of *H. h. hyaena*.

Distribution: Common in the lowlands of central and southern Iraq; uncommon in the northern mountains. Recorded from: Ur, Basra and Falluja (Cheesman 1920); between Amara and Sheikh Saad (Capper 1921); Falluja, Nahrwan, and Ad Dawr (Pitman 1922); Tyb River, Jabal Hamrin, and Ur (Pocock 1941); Bradost Mountain (Field 1955); near Haditha (Lawrence 1956); near Samarra (Harrison 1959); Jezira, c. 40 km W Mousel (Bodenheimer 1959); Mansuriya al Shatt (Hatt 1959); Erbil Liwa, Ctesiphon, Chamchamal, Baghdad, Baquba, Habbaniya, Ramadi and Sulaymaniya (Harrison 1968); Khan Al-Baghdadi (N-SB 2008; 2009); near Hammar Marsh (Haba 2009); Hammar Marsh (Abass 2013).

RR: Al-Ga'ara, Rutba (An-13).

Family: Felidae

Wild Cat *Felis silvestris* (Schreber, 1777)

Subspecies: *F. s. nesterovi* (Birula, 1916), confined to the forests and wooded valleys of northern Iraq; *Felis s. iraki* (Cheesman, 1921), restricted to the marshes and arid steppes of central and southern Iraq. Distribution: Wooded mountains, rooky steppes, and nearby marshes; nevertheless, the species appears to be rare. *Felis s. iraki* was recorded from: Sheikh Saad (Cheesman 1920); Baghdad and Diwaniya (Hatt 1959). *Felis s. nesterovi* was recorded from Nachr-Chasasch (Harrison 1968; Harrison & Bates 1991) and Peramagroon (Raza et al. 2012).

RR: *Felis s. iraki* near Habbaniya (An-13); Auda Marsh (Ma-14).

Jungle Cat *Felis chaus* (Schreber, 1777)

Subspecies: *F. c. furax* (de Winton, 1898), although intermediation with *F. c. chaus* (Güldenstädt, 1776) may occur.

Distribution: Widespread along the Tigris and Euphrates

Rivers. Recorded from: Amara, Qalat Salih, Madij, and Shahraban (Cheesman 1920); between Al-Qurna and Azir, Shatt al Adhaim, and Ad Dawr (Pitman 1922); Hilla Desert (Sanborn 1940); Abu Ghreb, near Akkarkuf (Bodenheimer 1959); Hila and Dujail (Hatt 1959); Khan Al-Baghdadi (N-SB 2008; 2009); Hammar Marsh (Abass 2013). Specimens collected in Mousel, Baghdad, Ramadi, and Habbaniya are included in the collections of the BMNH and HZM (Harrison 1968).

RR: Hammar Marsh (Ba-14).

Sand Cat *Felis margarita* (Loche, 1858)

Subspecies: *F. m. harrisoni* (Hemmer, Grubb and Groves, 1976).

Distribution: Confined to the desert and arid steppes of south western Iraq. Recorded from W Al-Najaf city and Al-Jufaira oasis in the desert of Al-Najaf Province (Mohammad et al. 2013).

RR: Takhadid (Mu-14) (Fig. 4).



Fig. 4. Adult male Sand Cat *Felis margarita* trapped in Muthana Province in south-western Iraq. Photo © Omar F. Al-Sheikhly 2014.

Caracal *Caracal caracal* (Schreber, 1776)

Subspecies: *C. c. schmitzi* (Matschie, 1912).

Distribution: Confined to the desert and arid steppes of the extreme western and southern Iraq. Recorded from: Basra (Metaxas 1891); 45 km from Rutba (Corkill 1930). Uncertain records from southern and western deserts of Iraq (Thalen 1975). Reported by locals from Faidhatt Al-Massad (Al-Sheikhly 2012).

RR: Hunters' reports from Ain Al-Faras in the Tharthar Valley (An-13).

Eurasian Lynx *Lynx lynx* (Linnaeus, 1758)

Subspecies: *L. l. dinuiki* (Satunin, 1915).

Distribution: Restricted to the forested mountains of extreme northern Iraq; it would appear to be rare. Recorded from: Zakho and Erbil Liwa (Hatt 1959; Harrison & Bates 1991); Barzan area (Raza 2013).

Leopard *Panthera pardus* (Linnaeus, 1758)

Subspecies: *P. p. saxicolor* (Pocock, 1927).

Distribution: Rare, restricted to the forested mountains of extreme northern Iraq. Recorded from: near Rawa (Musil 1927); Aqra and Rowanduz (Pocock 1930); Jabal Bradost (Field 1955); Harir Dag (Hatt 1959); Bamur Harrison (1968); Murdka of Darbandikhan, Mandili, and QaraDag (Al-Sheikhly 2012b); QaraDag (Raza et al. 2012).

RR: Suran Area (Du-13).

Cheetah *Acinonyx jubatus* (Schreber, 1775)

Subspecies: *A. j. venaticus* (Griffith, 1821).

Distribution: Probably extinct. Recorded from: near Busaiya (W Basra southern desert), K3 station, and H1 and H2 pumping stations in Syrian Desert (Corkill 1929); near Iraq-Saudi Arabia-Jordan borders (Hatt 1959; Harrison & Bates 1991).

Order Artiodactyla

Family: Bovidae

Wild Goat *Capra aegagrus* (Erxleben, 1777)

Subspecies: *C. a. aegagrus* (Erxleben, 1777).

Distribution: Confined to the mountain range of north-eastern Iraq: the largest population is in the area of Barzan. Recorded from: Bradost, Barzan near Aqra, and near Zawitta (Layard 1852); Baradost and Sarsank (Field 1951); Safin Dag, Zagarta, and Jabal Sinjar (Hatt 1959); Chamchamal Valley (Hoogstraal & Kaiser 1958); near Shaqlawa, Safin Dag, Harir Dag, Erbil Liwa, Nahiya, near Diyana, Rawandoz, and near Darbandikhan (Harrison 1968; Harrison & Bates 1991); Barazan, Qara Dag Mountain; Peramagroon Mountain (Al-Sheikhly 2012b); Qara Dag Mountain and Peramagroon Mountain (Raza 2013). Specimens collected in Berat Dag, Mousl Liwa, Jabal Zagarta, Sugrimah Dag, and Kurkuk Liwa are resident to the collection of the FMNH (Sanborn 1940). Recent observations with remarkable range extension were made in Al-Qosh in northwestern Mousel (Ali N. Salman pers. comm. 2014).

Mouflon *Ovis orientalis* (Gmelin, 1774)

Subspecies: *O. o. gmelini* (Blyth, 1841).

Distribution: Uncommon, restricted to the highlands of eastern and north-eastern Iraq. Recorded from: Zagros Mountain and mountains of Derbandikhan (Harrison 1968; Nadler et al. 1971; Harrison & Bates 1991); Jabal Himreen near Mandli in Diyala (Al-Sheikhly 2012b). Specimens collected in Kanispika, Baranand Dag are resident to the collection of the FMNH (Hatt 1959).

Arabian Oryx *Oryx leucoryx* (Pallas, 1777)

Subspecies: *O. l. leucoryx* (Pallas, 1777).

Distribution: Probably extinct; the last individual was shot in Maqil in southern Iraq in 1914 and kept in collection

at the BMNH (Hatt 1959). Specimens known from Iraq yet it is unclear if they have occurred on the eastern side of the Euphrates River (Harrison 1968; Al-Sheikhly 2012c).

Saudi Gazelle *Gazella sandiya* (Carruthers & Schwarz, 1935)

Subspecies: this species is distinct from Dorcas Gazelle (*G. dorcas*) according to Groves (1988). Status reviewed by Mallon & Kingswood (2001).

Distribution: Uncertain, probably extinct in the wild. There is only one record from the Ramadi-Rutba road in western Iraqi desert (Harrison 1968; Harrison & Bates 1991; Al-Sheikhly 2012c). A single specimen from southern Iraq was assigned to *G. subgutturosa marica* (Mallon & Kingswood 2001).

Goitred Gazelle *Gazella subgutturosa* (Guldenstaedt, 1780)

Subspecies: *G. s. marica* (Thomas, 1897), confined to the desert and arid steppes in western and southern Iraq; *G. s. subgutturosa* (Guldenstaedt, 1780) inhabits steppes of northern and eastern Iraq.

Distribution: Widespread. Recorded from: Euphrates valley (Lydekker & Blaine 1914); Samarra, Basra, Nasiriyah, and Amara, where was reported as *G. s. marica* (Cheesman 1920; Mallon & Kingswood, 2001); Sheikh Saad and NE Baghdad (Dollman & Burlace 1935); Chamchamal (Hoogstraal & Kaiser 1958; Harrison 1968); Faidhat Al-Massad, Faidhat Al-Dhaba'a, Al-Dheabeat, Al-Jazera Area near Haditha, Rutba, Al-Qa'cem, Jabal Makhool, Al-Sherqat, Baiji, Jabal Sinjar, Rabe'ea, Makhmoor, Jabal Himreen, Kafri, Kalar, Jalwla, Mandli, Badra, Khanaqeen, and Ser Qella at Garmyan area (Al-Sheikhly 2012c). Specimens collected in Erbil and Kurkuk are included in the collection of the BMNH (Hatt 1959). Specimens from Basra are resident to the collection of the BNHS, while those collected in Kurkuk, Baghdad, and Hinaidia are included in the collection of the FMNH (Harrison 1968).

RR: Small herds reported from Garmyan area (near Kalar), assigned to *G. s. subgutturosa* (Su-14).

Family: Cervidae

Fallow Deer *Dama dama* (Linnaeus, 1758)

Subspecies: *D. d. mesopotamica* (Brooke, 1875).

Distribution: Rare, a few individuals may still survive in the mountains of the extreme north eastern Iraq. Recorded from: Zakho (Ellerman & Morrison-Scott 1951); Bradost Mountain (Field 1955); between Maidan and Halabja (Harrison 1968; Harrison & Bates 1991).

European Roe Deer *Capreolus capreolus* (Linnaeus, 1758)
Subspecies: *C. c. coxi* (Cheesman & Hinton, 1923).

Distribution: Confined to the forested mountains of the extreme northern Iraq. Recorded from: Harir Dag and Mer-gasor (Hatt 1959). Subspecies *C. c. coxi* was described by Cheesman & Hinton (1923) on the basis of individuals observed in Zakho and Harir west of Rawandoz (Harrison 1968).

RR: Small herd reported from Barzan Area (M. Taib, Iraq, pers. comm. 2014).

Family: Suidae

Wild Boar *Sus scrofa* (Linnaeus, 1758)

Subspecies: *S. s. attila* (Thomas, 1912).

Distribution: Abundant, mainly along the Tigris and Eu-phrates Rivers and the southern marshes. Recorded from: Diyala, Kut al Imara, Baghdad, Ad Dawr, and Shatt al Ad-haim (Pittman 1922); Amara, Khaniqin, and Baradost (Sanborn 1940); Hawizeh (Drower 1949); Tigris River, south of Amara (Page 1954); north and south of Hilla and Mansuriyah al Shatt (Hatt 1959); near Majar, Chahala and Masharia Rivers, and Auaisij (Thesiger 1964); Lake Hab-baniya, Hadithah, Badra, Sulaymaniyah, and Sarsank (Harrison 1968); Fao and Hammar Marsh (Haba 2009); east of Hammar Marsh (Abass 2013); Hawraman Moun-tain (Lahony et al. 2013). Thesiger (1954) hunted 488 pigs in two years around Al-Hammar Marsh. Specimens col-lected in Baghdad and Baquba are resident to the BMNH, while those collected in Khaniqin, Wadi Hostoc-ki, Towaka, Zharir, Baradost, Chahala near Amara, and 30 km N Hilla are resident to the UoM (Harrison & Bates 1991).

RR: Recorded from 33 sites thrghout Iraq during 2013-2014.

Order Lagomorpha

Family: Leporidae

Cape Hare *Lepus capensis* (Linnaeus, 1758)

Subspecies: *L. c. arabicus* (Ehrenberg, 1833).

Distribution: Widespread, confined to the desert and arid steppes west of the Euphrates River. Ellerman & Morri-son-Scott (1951) reported the occurrence of this hare in Kuwait. Harrison & Bates (1991) reported an individual from Saqlawiya in western Iraq; recorded also from Cen-tral and Al-Hammar marshes (Haba 2009; Abass 2013); Hawraman Mountain (Lahony et al. 2013).

RR: Rutba, Ga'ara, and Al-Qa-ecm (An- 13); Teeb (My-13).

European Hare *Lepus (Eulagos) europaeus* (Pallas, 1778)
Subspecies: *L. e. commori* (Robinson, 1918), in the steppe, grassland, and foothill east of the Euphrates River; *L. e. syriacus* (Hemprich & Ehrenberg, 1832), confined to the arid steppes of the extreme north western Iraq.

Distribution: Widespread. Recorded from: Hindiya, Kut al Imara, Shatt al Adhaim, Jalam, the frontier of Arabia, the plain north of Samarra, Al Falluja, Hit, Amara, Al Ku-mait on the Tigris, Shahraban, and Twin Canals (Cheesman 1920); along the Tigris north of Ad Dam (Pit-man 1922); Baghdad and from Camp Rashid on its out-skirts (Sanborn 1940); Baghdad and Hilla (Hubbard 1955); Hilla, Mansuriya al Shatt, and Habbaniya (Hatt 1959); Chebaeish (Haba 2009).

RR: *L. e. commori* from Hor Dalmaj (Qa-13), Bahr Al-mil-ih (Ka-13); *L. e. syriacus* from 17 km NW Rutba (An-13).

Order Rodentia

Family: Sciuridae

Caucasian Squirrel *Sciurus (Tenes) anomalus* (Gmelin, 1778)

Subspecies: *S. a. pallescens* (Gray 1867), with seasonal variation in pelage colour.

Distribution: Abundant in the forested mountains of north-ern Iraq. Recorded from many localities in north eastern Iraq (Hatt 1959); Penjwin (Petter 1961); Koshck (Von Lehman 1966); Derbendikhan Dam (Harrison & Bates 1991); Hawraman Mountain (Lahony et al. 2013).

RR: Recoded from 34 sites in northern Iraq (12-14).

Family: Hystricidae

Indian Crested Porcupine *Hystrix (Hystrix) indica* (Kerr, 1792)

Subspecies: *H. i. indica* (Kerr 1792).

Distribution: Abundant along the Tigris and Euphrates val-leys, deserts and arid steppes, and mountains of northern Iraq. Recorded from many localities by Hatt (1959), Har-ri-son (1959), Smielowski (1978), Nadachowski et al. (1990) and Kadhim (1997); Peramagroon (Raza et al 2012); Hawraman Mountain (Lahony et al. 2013).

RR: Jabal Makhool, Al-Alam, Al-Cidir, Al-Tharthar Val-ley (Sa-13); Rutba, Ga'ara, Wadi Horan, Khan Al-Bagh-dadi, Al-Jezera (An-13); Jabal Himreen and near Hor Shwija (Di-13), Hor Dalmaj (Qa-13); Central Marshes (Th-14).

Family: Dipodidae

Euphrates Jerboa *Allactaga (Paralactaga) euphratica* (Thomas, 1881)

Subspecies: *A. e. euphratica* (Thomas, 1881).

Distribution: Relatively local in central and southern Iraq. Records were provided by Harrison (1959), Hatt (1959), Al-Robaae (1976), Kadhim & Wahid (1986) and Nada-chowski et al. (1990).

RR: Western Hammar Marsh (Th-13).

Lesser Egyptian Jerboa *Jaculus jaculus* (Linnaeus, 1758)
Subspecies: *J. j. lofusi* (Blanford, 1875), in the arid steppe of the eastern Euphrates basin; *J. j. vocater* (Thomas,

1921), in western and southern desert of Iraq.

Distribution: Widespread, in the desert and rocky steppes of central and southern Iraq. Recorded from: Az Zubeir (Ellerman & Morrison-Scott 1951); W Basra (Hatt 1959); 40 km E Rutba, Hatra (Nadachowski et al. 1990); Haur al Hasa, S Habbaniya (Harrison & Bates 1991); Al-Cidir (Al-Sheikhly 2013).

RR: Wadi Al-Tharthar (An-13).

Family: Gliridae

Large-eared Garden Dormouse *Eliomys melanurus* (Wagner 1840)

Subspecies: *E. m. melanurus* (Wagner, 1840).

Distribution: Restricted to the rocky steppe of north western Iraq. Recorded from: Hatra (Nadachowski et al. 1978); from c. 90 km SW of Mousel (Harrison & Bates 1991).

Forest Dormouse *Dryomys nitedula* (Pallas, 1779)

Subspecies: Possibly close to the Iranian subspecies *D. n. pictus* (Blanford, 1875).

Distribution: Confined to the Oak forests of Kurdistan. Recorded from: Sulaymaniyah in northern Iraq (Jawdat 1977; Harrison & Bates 1991).

Family: Spalacidae

Middle East Blind Mole Rat *Nannospalax ehrenbergi* (Nehring, 1898)

Iraqi populations of this variable taxon belong to the same karyotype (Coşkun et al. 2012). Although *N. ehrenbergi* is better regarded as a superspecies comprising several biological species (Hadid et al. 2012), uncertainty remains about the taxonomic rank as well as the nomenclature of the Iraqi karyotype, which is widely distributed also in southeastern Anatolia.

Distribution: Found in the steppe of northern Iraq. First description provided by Bate (1930), who reported bones of *N. ehrenbergi* from the Hazar Mard caves near Sulaymaniyah. Also recorded by Reed (1958) and Petter (1961) (Harrison & Bates 1991). Individuals collected in Ser Amadiya, Tim near Bermaneh (Harrison 1956) and Sarsank (Hatt 1959) were also assigned to this species. Recently recorded as *Spalax leucodon* from Hawraman Mts. (Lahony et al. 2013). The distribution in Iraq is summarised by Coşkun et al. (2012).

Family: Muridae

Eastern Broad-toothed Field Mouse *Apodemus mystacinus* (Danford & Alston 1877)

Subspecies: *A. m. mystacinus* (Danford & Alston, 1877).

Distribution: Confined to the Oak forests and wooded rocky cliffs of northern Iraq. Recorded from: Sarsank (Hatt 1959); Qali Ali Beg (Nadachowski et al. 1990; Harrison & Bates 1991).

Yellow-necked Field Mouse *Apodemus flavicollis* (Melchior, 1834)

Subspecies: *A. f. argyropuloi* (Heptner, 1948).

Distribution: Confined to the Oak forests of northern Iraq. Recorded from: Haj Omran and Sarsank (Hatt 1959); Saladin and Sulaymaniyah (Al-Shenawi et al. 1982; Harrison & Bates 1991).

Steppe Field Mouse *Apodemus witherbyi* (Thomas, 1902)

Subspecies: May be the species is represented by the sample collected in Qazvin (northern Iraq), which separated electrophoretically from both *A. sylvaticus* and *A. flavicollis*. To date, however, the specimens from Qazvin are considered closer to the latter (Darviche et al. 1979).

Distribution: Confined to the rocky mountain slopes of the extreme northern Iraq. Harrison (1956) reported this species from Ser Amadiya as *A. sylvaticus*. Hatt (1959) confirmed its occurrence at the same locality. Also recorded by Petter (1961) (Harrison & Bates 1991).

Roof Rat *Rattus rattus* (Linnaeus, 1758)

Subspecies: *R. r. rattus* (Linnaeus, 1758).

Distribution: Widespread, an urban pests mainly in settlements along the Tigris and Euphrates Rivers and their tributaries. Recorded from many localities in central and southern Iraq (Cheesman 1920; Hatt 1959; Nader 1968b; Al-Shenawi et al. 1982).

RR: Old Rasafa; Yarmook (B-13; 14).

Brown Rat *Rattus norvegicus* (Berkonhout, 1769)

Subspecies: *R. n. norvegicus* (Berkonhout, 1769).

Distribution: Widespread, mainly along the Tigris and Euphrates Rivers and their tributaries. Recorded from: Basra (Cheesman 1920; Hatt 1959); Baghdad (Kadhim et al. 1979; Al-Shenawi et al. 1982; Harrison & Bates 1991); Hammar Marsh (Abass 2013).

RR: 13 localities in Baghdad (B-13); Mashab River and Garmatt Ali (Ba-14).

House Mouse *Mus (Mus) musculus* (Linnaeus, 1758)

Subspecies: *M. m. praetextus* (Brants, 1827) and *M. m. bactrianus* (Blyth, 1846) occur in both eastern and western Iraq (Harrison 1972). However, further investigation is required.

Distribution: Widespread. Recorded from: Sinn Abtar and Twin Canals from Kut al Imara, Basra, Shaikh Saad, and Amara (Cheesman 1920); Habbaniyah, Baghdad, Sarsank, K-3, Hilla, Haj Omran, the region of Salahuddin, and Jarmo (Hatt 1959); Chebacish and Ashar (Haba 2009); also recorded by Nader (1968b), Al-Shenawi et al. (1982); Hammar Marsh (Abass 2013); Hawraman Mountain (Lahony et al. 2013).

RR: Al-Alam (Sa-13), Ramdi (An-13), and Yarmook area (B-14).

Short-tailed Nesokia *Nesokia indica* (Gray, 1830)

Subspecies: *N. i. boxtoni* (Thomas, 1919).

Distribution: Widespread in the riverine plains of both central and southern Iraq. Recorded from: Amara, Al Qurna, Aqar Quf, Shaikh Saad, and An Nasiriya (Cheesman 1920); Baghdad (Sanborn 1940); Cheesman's sites, Maqil and Hinaiidi (Ellerman 1948); Ur (Pocock 1934); Baghdad, Mansuriya al Shatt, Ramadi, and Babylon (Hatt 1959); recorded also by Petter (1961), Nader (1968b), Al-Robaee (1977), Kadhim (1981) Al-Shenawi et al. (1982); and Abass (2013).

Long-tailed Nesokia *Nesokia bunnii* (Khajuria, 1981)

Originally described under the genus *Erythronesokia* by Khajuria (1981), later on it was proved to be a distinctive species of *Nesokia* (Al-Robaee & Felten 1990).

Distribution: Current status is unknown. Recorded only in the marshes at the confluence of the Tigris and Euphrates Rivers in south eastern Iraq (Khajuria 1981; Al-Robaee & Felten 1990), the species could also possibly occur in Al-Hawizeh Marsh straddling the Iraq-Iran south eastern border.

Family: Cricetidae

Gray Dwarf Hamster *Cricetulus migratorius* (Pallas, 1773)

Subspecies: *C. m. cinerascens* (Wagner, 1848).

Distribution: Abundant in cultivated lands, forests, and steppes mainly of northern Iraq. Individuals were collected in Ser Amadiya by Harrison (1956). A specimen included in the collection of the FMNH was trapped at Jarmo (Hatt 1959). Also recorded by Petter (1961) and Kadhim (1975) (Harrison & Bates 1991).

Baluchistan Gerbil *Gerbillus (Hendecapleura) nanus* (Blanford, 1875)

Subspecies: *G. n. nanus* (Blanford, 1875), in eastern Iraq; *G. n. arabium* (Thomas, 1918), confined to the desert of south western Iraq.

Distribution: Widespread, in deserts and arid steppes of central and southern Iraq. Recorded from: Ali Al-Gharbi by Petter et al. (1957); specimens from Basra Liwa are included in the collection of the UMC (Harrison & Bates 1991).

Wagner's Gerbil *Gerbillus (Hendecapleura) dasyurus* (Wagner, 1842)

Subspecies: *G. d. dasyurus* (Wagner, 1842).

Distribution: Widespread in the steppic deserts of central and western Iraq. Recorded from: c. 11 km SE H2 pumping station in western Iraq (Harrison 1956c); Haditha (Hatt 1959; Harrison & Bates 1991).

RR: Wadi Al-Tharthar (An-13).

Mesopotamian Gerbil *Gerbillus (Hendecapleura) mesopotamiae* (Harrison, 1956)

Subspecies: *G. m. mesopotamiae* (Harrison, 1956), with

some individual and local variation.

Distribution: Widespread in arid terrains of central and southern Iraq. Harrison (1956) reported the species in the surroundings of Amiriya. Recorded from: Lake Habbaniya, Baghdad, K-3, Basra; Haur Al Hasa, Al-Jadriyah, Ain Tina, 4 km S Falluja, 10 km W Baghdad, Rashidiya, 4 km S Abu Ghraib, and Um al Khanazeer Island (Hatt 1959); 5 km SE Najaf (Nasher 1970); Ramadi Liwa (Nadachowski et al. 1990). Specimens from Ali Gharbi are included in the collection of the PM, while those from Baghdad and Baquba are included in the collection of the BRCB (Harrison & Bates 1991).

Cheesman's Gerbil *Gerbillus (Gerbillus) cheesmani* (Thomas, 1919)

Subspecies: *G. c. cheesmani* (Thomas, 1919).

Distribution: Confined to open sandy hummocks with sparse vegetation of central and southern Iraq. Recorded from: Along the west bank of the Euphrates River (SW Al Falluja, near Haur al Hasa, Amiriya: Harrison 1956); Lake Habbaniya (Hatt 1959; Harrison & Bates 1991).

Indian Gerbil *Tatera indica* (Hardwicke, 1807)

Subspecies: *T. i. taeniura* (Wagner, 1843).

Distribution: Widespread. Recorded from: Amara, Sinn Abtar, Kut al Imaara, Baghdad, Aqarkuf, Sheikh Saad, Shahraban, and Baiji (Cheesman 1920); Kasimain and Baghdad (Ellerman 1948); near Habbaniya (Harrison 1956c); Ali Gharbi (Petter 1957); Tell Imlihiye (Kock & Nader 1983); Hatra (Nadachowski et al. 1978; Harrison & Bates 1991). Further records were provided by Kadhim (1998).

Persian Jird *Meriones (Parameriones) persicus* (Blanford, 1875)

Subspecies: *M. p. persicus* (Blanford, 1875).

Distribution: Restricted to the mountains of northern Iraq. Recorded from: Kani Mase and Ser Amadia (Harrison 1956c); Penjwin and Jabal Batiwa (Petter et al. 1957); Salahadin, Shaqlawa, and Jarmo (Hatt 1959).

Tristram's Jird *Meriones (Pallasiomys) tristrami* (Thomas, 1892)

Subspecies: *M. t. lycaon* (Thomas, 1919), with ochraceous buff dorsal pelage.

Distribution: Confined to the Oak forests of northern Iraq. Recorded from: Dohuk (Ellerman 1948); Bakrajo in Sulaymaniyah and Sarsank (Hatt 1959). Petter et al. (1957). Kock & Nader (1983) and Nadachowski et al. (1990) provided further records. A few specimens are included in the collection of the HZM (Harrison & Bates 1991).

Libyan Jird *Meriones (Pallasiomys) libycus* (Lichtenstein, 1823)

Subspecies: *M. l. syrius* (Thomas, 1919), confined to the

desert steppe of western Iraq; *M. l. erythronus* (Gray, 1842), occurs in the eastern region of the Euphrates basin. Distribution: Widespread. Recorded from: Az Zubair W Basra (Ellerman 1948); Amiriya and Al Jazira SW of Samarra (Harrison 1956c); At Tuba, Basra (Hatt 1959). Also reported by Heptner (1940) and Petter et al. (1957); Al-Cidir (Al-Sheikhly 2013).

Sundevall's Jird *Meriones (Pallasionmys) crassus* (Sundevall, 1842)

Subspecies: *M. c. crassus* (Sundevall, 1842), confined to the arid steppes of western Iraq; *M. c. charon* (Thomas, 1919) occurs in the eastern region of the Euphrates basin. Distribution: Widespread. Recorded from: Kasimain and Az Zubeir (Cheesman 1920); Haur al Hasa and Jazira (Harrison 1956c); Ali Gharbi and Kurkuk (Petter et al. 1957); 150 km NW Basra, Haditha, 24 km W Ramadi, 32 km W Baghdad, and Balad (Hatt 1959); Balad (Harrison 1972; Harrison & Bates 1991).

Transcaucasian Mole Vole *Ellobius (Afganomys) lutescens* (Thomas, 1897)

Subspecies: Possibly *E. l. lutescens* (Thomas, 1897). Distribution: Probably still present on the mountains of northern Iraq. Fossils were discovered in the caves of Hazar Mard (Bate 1930) and Shanidar (Hatt 1959). Hatt (1959) reported that the species might still inhabit the mountains of northern Iraq. Baltazard & Seydian (1960) reported the occurrence of some specimens from Penjwin, whereas Petter (1961), who examined the same collection, did not (Harrison & Bates 1991).

Eurasian Water Vole *Arvicola amphibius* (Linnaeus, 1758)

Subspecies: *A. a. persicus* (de Filippi, 1865). Distribution: Restricted to the mountains of northeastern Iraq; recorded from Penjwin (Petter 1961; Harrison & Bates 1991).

RR: Chebaeish (Central Marshes, southern Iraq) yet without supporting material (N. Abod. pers. comm. 2014).

Social Vole *Microtus (Microtus) socialis* (Palas, 1773)

Subspecies: Harrison and Bates (1991) included *gnentheri* and *irani* under *M. socialis*. However, *M. irani* has been separated as a distinct taxon (Kefelioglu & Kryštufek 1999; Golenishchev et al. 2002).

Distribution: Confined to the mountains and foothills of northern Iraq. Recorded from: Ser Amadiya (Harrison 1956a); Sulaymaniyah and Sarsank (Hatt 1959); Penjwin (Petter 1961); Hawraman Mountain (Lahony et al. 2013). A few specimens are included in the collection of both BMNH and HZM (Harrison & Bates 1991). Ellerman (1948) reported the occurrence of some specimens from "Baghdad", but it is wisely questioned whether they really came from that locality (Hatt 1959).

Order Cetacea

Family: Delphinidae

Indo-Pacific Humpbacked Dolphin *Sousa chinensis* (Osbeck, 1765)

Distribution: Marine coasts of southern Iraq. The species (under the name *Sotalia lentiginosa*) was recorded from Khor Al Zubeir (Al-Robaee 1970a).

Indo-Pacific Bottlenose Dolphin *Tursiops aduncus* (Ehrenberg 1833)

Distribution: Marine coast of southern Iraq. Reported from Rass Al-Mataf (near Fao) in the northern part of the Arabian Gulf (Al-Robaee 1974).

Finless Porpoise *Neophocaena phocaenoides* (G. Cuvier, 1829)

Distribution: Marine coast of southern Iraq. Recorded from the Iraqi territorial water c. 37 km S Fao; another specimen was reported from Fao (Al-Robaee 1975).

Family: Balaenopteridae

Blue Whale *Balaenoptera musculus* (Linnaeus 1758)

Distribution: Marine coast of southern Iraq. Uncertain status; listed by Mahdi & George (1969) but without providing further details.

Bryde's Whale *Balaenoptera edeni* (Anderson 1879)

Distribution: Marine coast of southern Iraq. Recorded from: Khor Al Zubeir (6.4 km NW of port Umm Qasr) (Mahdi 1967; Al-Robaee 1969).

Humpback Whale *Megaptera novaeangliae* (Borowski 1781) (Arabian Sea sub-population)

Distribution: Marine coast of southern Iraq. Specimens collected near Fao and Shatt Al-Arab are resident to the collection of the BRCB (Hatt 1959; Al-Robaee 1970b).

DISCUSSION

Historical framework

A checklist of the mammals of Iraq was urgently required in order to support conservation plans for the Iraqi fauna. We reviewed eight major orders including 28 families, 65 genera and 93 species. This manuscript represents the first systematic checklist of wild mammals prepared for Iraq since the 1950s, and includes many new species recorded since Hatt's masterpiece. Moreover, Hatt (1959) included 12 species that were re-evaluated and eventually assigned to other taxa by Harrison & Bates (1991): Bicolored White-toothed Shrew (*Crocidura leucodon persica*) assigned to Lesser White-toothed Shrew (*C. suaveolens*), the European Hedgehog (*Erinaceus europaeus*) assigned to East European Hedgehog (*E. concolor*), Babylonian

Sheath-tailed Bat (*Taphozous kachhensis babylonicus*) assigned to Naked-bellied Tomb Bat (*T. nudiventris magnus*), Northern Bat (*Eptesicus nilssoni nilssoni*) assigned to Botta's Serotine (*E. botaie*); V: Hingston's Serotine (*Eptesicus sodalis hingstoni*) assigned to Botta's Serotine (*E. botaie*), Cox's Pipistrelle (*Pipistrellus coxi*) assigned to Rüppell's Pipistrelle (*P. ruppellii*), the Indian Red Fox (*Vulpes v. pusillus*) assigned to the Arabian Fox (*V. v. arabica*), the European Hare (*Lepus europaeus conradi*) assigned to Cape Hare (*L. capensis conradi*), the Persian Squirrel (*Sciurus anomalus*) assigned to the subspecies *S. a. pallescens*, Wagner's Gerbil [*Gerbillus (Hendecapleura) dasyurus*] assigned to Harrison's Gerbil [*G. (H.) mesopotamiae*], Turkish Jird (*Meriones blackleri blackleri*) assigned to Tristram's Jird [*M. (M.) tristrami*], and the Persian Vole (*Microtus irani*) assigned to the Social Vole (*M. socialis*).

Later on, further observations were provided by Harrison (1964; 1968; 1972) and Harrison & Bates (1991). Nevertheless, eight new records obtained in 2012 and 2013 were added to the present checklist: Syrian Jackal (*Canis aureus syriacus*) from Hussaiba, 7 km NW Al-Qa-eem, western Iraq (Al-Sheikhly 2012a), Arabian Wolf (*Canis lupus arabs*) from Rutba, western Iraq (Al-Sheikhly 2012b), Indian Grey Mongoose (*Herpestes edwardsi*) from Kurdistan, northern Iraq (Al-Sheikhly & Mallon 2013), Least Weasel (*Mustela nivalis*) from Kurdistan, northern Iraq (Raza 2013), Sand Cat (*Felis margarita*) from desert of Al-Najaf Province (Mohammad et al. 2013), Syrian Cape Hare (*Lepus capensis syriacus*) from Rutba, western Iraq (Al-Sheikhly, in litt.), Mediterranean Horseshoe Bat (*Rhinolophus euryale*) from Kurdistan, northern Iraq (Al-Sheikhly et al. 2015), and Geoffroy's Myotis (*Myotis emarginatus*) from Kurdistan, northern Iraq (Al-Sheikhly et al. 2015).

Present checklist

Among the 93 species recorded in Iraq, 24 were evaluated by the IUCN (one species listed as extinct, one species as Critically Endangered, four species as Endangered, eight species as Vulnerable, seven species as Near Threatened, and three species as Data Deficient) (Table 2). In this context, the above-mentioned Smooth-coated Otter, a flagship species of Iraq is worth of mention. During the 1980s and 1990s this species was guessed to be extinct due to habitat loss and fragmentation as well as to over-hunting, but it has been rediscovered very recently (Omer et al. 2012; Al-Sheikhly & Nader 2013; Al-Sheikhly et al. 2014).

The strategic geographical position of Iraq provided the local mammals with a historical natural connection to the fauna of southern Turkey, western Iran, eastern Syria and the north eastern part of the Arabian Peninsula. Hence, it

did not come as a surprise that six Arabian species were found west of the Euphrates River: the Arabian subspecies of the Lesser Mouse-tailed Bat (*Rhinopoma hardwickii arabium*), the Arabian Wolf (*Canis lupus arabs*), the Arabian Fox (*Vulpes vulpes arabica*), the Arabian Cape Hare (*Lepus capensis arabicus*), the Arabian Sand Gazelle (*Gazella subgutturosa marica*), and the Arabian subspecies of Baluchistan's Gerbil (*Gerbillus namus arabium*). In addition, the Sand Cat (*Felis margarita harrisoni*), a species confined to the Arabian Desert, was recently recorded in Iraq as well. Furthermore, the Syrian Desert, the monotonic landscape shared between eastern Syria and western Iraq, which extends until the western bank of the Euphrates River, is inhabited by five species: the Syrian Jackal (*Canis aureus syriacus*), the Syrian Stone Marten (*Martes foina syriaca*), the Syrian Marbled Polecat (*Vormela peregusna syriaca*), the Syrian Striped Hyaena (*Hyaena hyaena syriaca*) and the Syrian Cape Hare (*Lepus capensis syriacus*). Finally, the mammalian fauna of Iraq is also naturally connected to the zoogeographic realm of Persia, a territory stretching mainly east of the Tigris River and along the border with Iran. Eight species can be found so far in the forested mountains, rocky valleys, and grassy steppes of this region: the Iranian Wolf (*Canis lupus pallipes*), the Persian Leopard (*Panthera pardus saxicolor*), the Iranian (Asiatic) Cheetah (*Acinonyx jubatus venaticus*), the Persian Goitred Gazelle (*Gazella subgutturosa subgutturosa*), the Wild Goat (*Capra aegagrus*), the Persian Squirrel (*Sciurus anomalus*), the Persian Jird [*Meriones (Parameriones) persicus*], and the Persian Water Vole (*Arvicola amphibius persicus*).

During the Iraq war in 2003, vandalism against the Biological Research Centre of Baghdad (BRCB) occurred and, as a consequence, many valuable specimens of the Iraqi fauna were lost or damaged. When we examined mammal specimens kept in the BRCB collection we also noticed that many of them were decomposed due to long-term storage. Unfortunately, substitute material was not available especially for Soricomorpha, Chiroptera and Rodentia. Nevertheless, we would like herein to focus on a few valuable mammal specimens collected in Iraq and described as new taxa. The Haditha Mouse-tailed Bat (*Rhinopoma hadithaensis*) was first described by Khajuria (1988) based on a few specimens discovered in Haditha (western Iraq) and now resident to the collection of the BRCB. According to their morphology and, especially, to the cranial features provided by Khajuria (1988), Kock et al. (2001) regarded *R. hadithaensis* as junior synonym of the Greater Mouse-tailed Bat (*R. microphyllum*). However, the status of *R. hadithaensis* remains uncertain and further investigation is needed. Other valuable specimens (study skin kept at the BMNH and live cub) belong to the Iraq Smooth-coated Otter (*Lutrogale perspicillata maxwelli*), collected by Gavin Y. Maxwell (Hayman 1959). The otter skin was found in the village of

Abusakhair (Faraijat tribe, c. 56 km SE of Amara, along the Tigris River) and included in the collection of the BMNH. The live cub was probably found in a tumulus island village called Daub, c. 19 km NW of Al-Azair (west of the Tigris River: Hayman 1956; Maxwell 1957, 1960; Al-Sheikhly & Nader 2013; Al-Sheikhly et al. 2014). After 1980s *L. p. maxwelli* was believed to be extinct, but during field surveys carried out in 2007–2012 the occurrence of *L. p. maxwelli* in southern Iraqi marshes was proved by Al-Sheikhly & Nader (2013). Additionally, another isolated population of *L. perspicillata* was found in Kurdistan (northern Iraq), this finding representing a remarkable extension of the species range known so far (Omer et al. 2012; Al-Sheikhly & Nader 2013). The Long-tailed Nesokia (*Nesokia bunnii*) was described by Khajuria (1981) within the genus *Erythronesokia* on the basis of two individuals collected in Al-Qurna (southern Iraq) and presently included in the collection of the BRCB. This species can be distinguished from the similar Short-tailed Nesokia by its large size, cranial features, long tail, redness of the dorsal pelage, and incipient development of the lower incisor root. Al-Robaee & Felten (1990) showed that Khajuria's (1981) *N. bunnii*, indeed, represents a distinct species. Harrison & Bates (1991) comprehensively examined Khajuria's record and concluded that it could be a large specimen of Short-tailed Bandicoot Rat (*Nesokia indica*), with an abnormal long tail possibly reflecting its ecological adaptation to the aquatic habitat. However, more samples from the Basra Province are required to confirm the taxonomic identity of this taxon in Iraq.

We found that hunting and trapping represent the main threats to the wild mammals of Iraq. Indian Crested Porcupine, Cape Hare, and Jerboas are widely hunted for meat consumption and fur by local people, especially in central and western Iraq. On the contrary, such practices are forbidden in southern Iraq. The spines of the porcupine are used to decorate houses and cars, the tails of both hares and jerboas are used to make keychains, while the fur is used to create handmade souvenirs. Goitred Gazelle, Wild Goat, and Mouflon are heavily hunted to be consumed as food or trapped to be raised as domesticated pets (Al-Sheikhly 2012b). The skulls of hunted gazelles and goats, especially those with big horns, are usually mounted and/or hanged on the front wall of the hunters' houses to testify the success of their hunting trips. Local farmers hunt wild boars for purpose of eradication, as they considered this species as a pest. Locals also hunt Fox, Jackal, Wolf, Striped Hyena, Honey Badger, Jungle Cat and Leopard according to traditional practices and/or myths (Hatt 1959; Harrison 1972). The Bedouins are known to chase wolves and hyenas in the western desert of Iraq in order to collect their eyes, claws and teeth, which are all used as symbols of glory according to the Arabian tradition. Alternatively, Bedouins usually trap wolf cubs in order to raise them as

pets. More in general, a conflict between the previous carnivore species and shepherds, farmers and hunters is ongoing, the local people being constantly engaged to eliminate these species whenever possible. Especially wolves and leopards are considered dangerous to humans and destructive to cattle herds (Fig. 2). Nevertheless, the European Otter and the Smooth-coated Otter are widely hunted for their fur throughout Iraq. Such a practice led the populations of both species to the edge of the extinction. Otters' fur is used as a waterproof sac, which can be filled with illegal imports and inserted in the gasoline tank of smugglers' vehicles (Al-Sheikhly & Nader 2013; Al-Sheikhly et al. 2014). Iraqi farmers and hunters regularly collect juvenile Persian Squirrel and Small Indian Mongoose in spring. Squirrels are mainly trapped in northern Iraq before being carried out to the animal markets of Baghdad, Mousel and Kurkuk. Many of them usually die due to serious injuries caused by trapping and/or transportation before they can be sold as tamed pets. Hunters of central and southern Iraq monitor the lactating female mongooses and chase them at their dens in order to collect young individuals. These latter are then usually sold to local farmers. Young mongooses, indeed, are usually trained to control rodents and insects in farms and settlements.

Unfortunately, illegal trapping and trafficking of autochthonous mammalian species is widely performed in Iraq. The weakness of the wildlife hunting legislation allows unauthorised local hunters to trap many wild animals for purpose of export to neighbouring countries. For instance, young Sand Gazelle and Wild Goat are trapped during the breeding season in the western desert and north-eastern mountains of Iraq, and then shipped to neighbouring countries (Al-Sheikhly 2012c). Youngs of the Brown Bear are trapped in many localities of northern Iraq (Kurdistan) and sold as pets in the animal markets of Baghdad. Nevertheless, the trade of exotic species to Iraq does frequently occur as well, this representing an additional threat to the local biota. For instance, the African Lion (*Panthera leo*), the North-West African Cheetah (*Acinonyx jubatus hecki*), and the Bengal Tiger (*Panthera t. tigris*) are regularly imported and sold in the animal markets of Iraq. The price for each specimen ranges between US\$ 1,700 and US\$ 4,000, cubs being the most requested items.

It is clear that the conflict between man and wild species is leading to a rapid decline of many animal populations in Iraq. The lack of scientific knowledge and awareness about the wild fauna among local farmers and hunters, the ever-increasing hunting pressure, poaching and related illegal trade of animals as well as ongoing habitat loss and fragmentation represent the main threats impacting wild mammals of Iraq. Despite the huge efforts proposed by the Iraqi authorities in order to protect the wild mammalian fauna, further enforcement of present hunting legislation is essential, as Iraq became a signatory country to the Con-

vention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

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GEOGRAPHICAL GAZETTEER**Al-Anbar Province (An)**

Al-Faluja (Falluja; Feluja): 33°21'N43°46'E; Abu Al-Jir: 33°16'N42°53'E; Abu Ghreb (Abu Graib): 33°28'N44°17'E; Al-Dhebeate (Al-Thebeatt): 32°49'N43°11'E; Al-Ga'ra: 33°29'N40°26'E; Al-Jezera (Jezaratt Al-Anbar): 34°11'N42°49'E; Al-Qa-cem: 34°22'N41°06'E; Anah (Ana): 34°28'N41°56'E; Cheleabat: 32°18'N39°47'E; Faidhat Al-Massad: 32°55'N40°13'E; Faidhat Al-Dhaba'a: 32°58'N40°20'E; H1 station: 33°40'N39°57'E; H2 station: 33°16'N40°40'E; Habbaniya: 33°22'N43°35'E; Hadithah: 34°07'N42°23'E; Haur al-Hasa: 33°12'N43°45'E; Hit: 33°38'N42°49'E; Hussai-ba: 34°23'N40°59'E; K3 station: 32°55'N39°45'E; Lake Habbaniya: 33°17'N43°29'E; Nikheab: 32°02'N42°15'E; Qasr al-Helqum: 33°48'N40°35'E; Rahaliyah: 32°46'N43°23'E; Ramadi (Ar Ramadi): 33°27'N43°19'E; Rawa: 34°28'N41°55'E; Razaza Lake: 32°43'N43°31'E; Rutba (ArRutba): 33°03'N40°18'E; Saqlawiya: 33°24'N43°41'E; Shamiyah Desert: 30°20'N46°40'E; Sheikh Hadid: 34°11'N42°22'E; Sin Al-Dhibban (Thuban; Zeban): 33°23'N43°36'E; T1 station: 34°15'N41°20'E; Wadi Arar: 31°27'N41°38'E; Wadi Horan: 33°54'N41°57'E; Wadi Haqlaniya (Haqlan): 34°05'N42°27'E.

Babel (Babylon) Province (Bb)

Al-Mahmodiyah: 32°29'N44°25'E; Hilla: 32°32'N44°13'E; Hindiya (Sadatt Al-Hindiya): 33°04'N44°22'E.

Baghdad Province (B)

Agergoof (AqarQuf; Aqarkuf; Akkarkuf): 33°24'N44°21'E; Al-Adhamiyah: 33°22'N44°21'E; Al-Kadmiyah: 33°22'N44°20'E; Al-Rashdiyya (ArRashdiyya): 33°32'N44°21'E; Amiriya: 33°22'N44°32'E; Dor'ah (Dora): 33°15'N44°23'E; Jadriyah and Umm Al-Khanazeer Island: 33°17'N44°23'E; Mustansiriyah: 33°22'N44°24'E; Old Rasafa: 33°20'N44°24'E; Rashidiya: 33°25'N44°22'E; Rustamiyah: 33°16'N44°32'E; Yarmook: 33°17'N44°20'E; Zaafaraniyah: 33°13'N44°33'E.

Basra Province (Ba)

Abu Al-Khasib: 30°26'N48°00'E; Al-Masshab: 30°39'N47°28'E; Al-Qurna (Gurna): 31°01'N47°27'E; Ashar: 30°30'N47°50'E; At Tanumah: 30°31'N47°51'E; At Tuba: 30°27'N47°30'E; Basra city: 30°30'N47°48'E; Fao: 29°55'N48°30'E; Jabal Sanam: 30°06'N47°42'E; Khor Al-Zubeir: 30°02'N47°58'E; Kut as Sayyid: 30°31'N47°49'E; Majnoon: 31°12'N47°30'E; Maqil (Ma'qal): 30°33'N47°46'E; Rass Al-Beisha: 29°55'N48°33'E; Shaiba (Shaiba; Shuaiba): 30°24'N47°41'E; Shatt Al-Arab: 30°26'N48°09'E; Umm Al-Rassas: 30°26'N48°07'E; Zubeir (Az-Zubeir): 30°24'N47°45'E.

Diyala Province (Di)

Adhaim (Shatt al Adhaim): 34°01'N44°19'E; Al-Miqdadiyah: 33°58'N44°58'E; Al-Khalis: 33°51'N44°32'E; Baladruz: 33°41'N45°05'E; Baquba (Baqubah): 33°45'N44°40'E; Ctesiphon: 33°06'N44°36'E; Jalwla: 34°17'N45°10'E; Kafri: 34°41'N44°58'E; Khaniqin: 34°20'N45°22'E; Lake Himreen: 34°10'N44°59'E; Madain: 33°05'N44°35'E; Mandli: 33°44'N45°34'E; Mansuriya al Shatt: 33°45'N44°24'E; Nahrwan (Nahrawan): 33°22'N44°42'E; Shahraban: 33°59'N44°56'E.

Duhok Province (Du)

Banaman: 36°23'N44°08'E; Bebaiddi: 37°07'N43°27'E; KaniMase (KaniMasi): 37°13'N43°25'E; Sarsank (Sersang): 37°03'N43°15'E; Ser (Ser') Amadia (Amadiya): 37°08'N43°27'E; Zakho: 37°08'N42°41'E; Zaweta (Zawitta): 36°55'N43°12'E.

Erbil Province (Er)

Bradost Mountain (JabalBradost): 36°46'N44°21'E; Barzan: 36°55'N44°03'E; Bola: 36°45'N44°42'E; Diyana: 36°39'N44°32'E; Diyana (Soran): 36°41'N44°35'E; Gali (Qali) Ali Beg: 36°38'N44°25'E; Hais: 37°13'N43°25'E; Haj Omran: 36°40'N45°05'E; Harir (HarirDagh): 36°27'N44°23'E; Jabal Zhargahta: 35°18'N45°17'E; Kasimain: 33°22'N44°20'E; Makhmoor: 35°45'N43°35'E; Mergasor: 36°50'N44°19'E; Rawanduz (Rowanduz): 36°38'N44°32'E; SafinDagh (Jabal-Safin): 36°23'N44°18'E; Shanidr Cave: 36°50'N44°13'E; Shaqlawa: 36°23'N44°18'E; Shirin Mountain: 36°58'N44°06'E; Suran (Soran) Arca: 36°39'N44°32'E.

Karbal'a Province (Ka)

Uqhaidhir (Ukhaidir): 32°26'N43°36'E; Al-Tar (Al-Tar caves): 32°28'N32°46'E; EinTamur (Shthatha): 32°33'N32°29'E.

Kurkuk Province (Ku)

Chamchamal-Jarmo: 35°34'N44°55'E; Alton Kobri: 35°44'N44°09'E; TaqTaq: 35°53'N44°36'E.

Mayssan Province (Ma)

Abusakhair: 32°32'N47°19'E; Al-Kumait: 32°01'N46°43'E; Ali Gharbi: 32°28'N46°42'E; Al-Maimona: 31°41'N46°58'E; Amara: 31°50'N47°08'E; Azair: 31°20'N47°26'E; Biet Mohammad: 31°50'N37°10'E; Chahala: 31°40'N47°18'E; Daub: 31°22'N47°14'E; Hawizeh: 31°39'N47°40'E; Kut al Imara: 32°30'N45°49'E; Majar al Kabir: 31°34'N47°09'E; Musharah River: 31°50'N47°13'E; Nachr-Chasaseh: 30°50'N47°10'E; QalatSalih: 31°32'N47°19'E; Sinn Abtar: 32°30'N45°49'E; Teeb: 32°03'N47°15'E; Umm-Al-Ni'aj: 31°37'N47°36'E.

Nenawa (Nineve) Province (Ne)

Ain Tina: 35°35'N42°43'E; Ain Zala (Ain Zalah): 36°44'N42°34'E; Almawan: 36°25'N44°13'E; Aqra (Akra): 36°45'N43°54'E; Aski-kalak: 36°16'N43°38'E; Atrosh: 36°50'N43°20'E; Cora: 36°21'N44°10'E; Fishkhaboor: 37°03'N42°22'E; Hamam Al-Alil: 36°10'N43°16'E; Hatra (Al Hadr): 35°34'N42°42'E; Jabal Sinjar: 36°23'N41°52'E; Mousel city: 36°20'N43°06'E; Narwah: 36°42'N44°10'E.

Muthana Province (Mu)

Busaiyah (Busaiya): 30°5'N46°7'E; Samawa: 31°18'N45°18'E.

Najaf Province (Na)

Bahr Al-milih (Bahr Al-Najaf): 31°59'N44°15'E; Najaf city: 31°59'N44°19'E; Seriya: 33°24'N43°41'E.

Qadissiyah Province (Qa)

Ad Dwaniyah: 31°58'N44°56'E; Al-Hamza: 31°43'N44°58'E; Al-Shamiyah: 31°57'N44°36'E; Ash-Shinaffya: 31°35'N44°39'E; Dalmaj (HorDalmaj): 32°9'N45°31'E; Ghamaz (Gamas): 31°44'N44°37'E.

Salahadin Province (Sa)

Tikrit: 34°35'N43°40'E; Ad Dawr (Daur): 34°29'N43°49'E; Ain Al-Faras: 34°16'N43°11'E; Al-Alam: 34°42'N43°41'E; Al-Jezera (Jezerratt Samarra): 35°00'N42°00'E; Baiji (Beaji): 34°56'N43°29'E; Balad: 34°00'N44°09'E; Balad (Beled): 33°58'N44°11'E; Cidir: 34°44'N44°03'E; Dejal: 33°50'N44°14'E; Dholuiya: 34°05'N44°12'E; Duz-khurmato (Tooz): 34°52'N44°37'E; Jalam (Jalam Albu Ajeel): 34°35'N43°53'E; Jabal Himreen: 34°59'N43°43'E; Makhool (Jabal Makhool): 35°07'N43°26'E; Qala't Asharqat: 35°27'N43°13'E; Samara: 34°12'N43°52'E; Sharqat: 35°29'N43°14'E; Tarmiya: 33°40'N44°22'E; Wadi Al-Tharthar: 34°16'N43°27'E.

Sulaymaniyah Province (Su)

Ahmad Awa: 35°17'N46°03'E; Baksai: 32°53'N46°26'E; Chamchamal: 35°32'N44°50'E; Chami-Rezan: 35°48'N45°01'E; Darbandikhan (Derbendi Khan): 35°18'N45°47'E; Halabja: 35°10'N45°59'E; Hawaraman Area: 35°13'N46°06'E; Hazar Mard: 35°30'N45°20'E; Zagarta (Jabal Zagarta; Sargat): 35°16'N46°06'E; Kalar: 34°36'N45°19'E; Kanispika: 35°27'N45°23'E; Koshek: 35°16'N45°47'E; Little Zab: 35°54'N44°58'E; Maidam: 34°55'N45°37'E; Mawat: 35°57'N45°24'E; Murdka (Mortka): 35°03'N45°49'E; Parazan: 35°35'N45°49'E; Penjwin: 35°35'N45°57'E; Peramagroon: 35°46'N45°13'E; QaraDaq (Karadagh): 35°17'N45°21'E; Qashqulai: 35°55'N44°57'E; Sulymaniyah city: 35°33'N45°25'E; Taqia: 35°37'N44°57'E; Zagros Mountains (Jabal Zagros): 36°00'N45°00'E.

ThiQar Province (Th)

An Nasseriyah: 31°03'N46°16'E; Abu Ajaj: 39°49'N46°36'E; Abu Zirig: 31°06'N46°38'E; Al-Eslah: 31°09'N46°36'E; Al-Fhood: 30°58'N46°43'E; All Jweaber: 30°54'N46°38'E; Al-Ta'r: 30°56'N56°50'E; Chebaeish: 30°57'N46°59'E; Hor (Hour) Al Hammar: 30°50'N47°10'E; Kamisiyah: 30°46'N46°29'E; Kermashiya: 30°47'N46°37'E; Naheat Al Hammar: 30°57'N46°50'E; QarmattBani Sced: 30°52'N46°34'E; Suq Al-Sheikh: 30°52'N46°29'E; Ur: 30°57'N46°06'E; Zichri (Az Zichri): 31°03'N47°13'E.

Wasit Province (Wa)

Aziziyha: 32°54'N45°05'E; Badra: 33°05'N45°59'E; Kut: 32°29'N45°50'E; Numanayah: 32°33'N45°25'E; Sewara: 32°54'N44°47'E; Sheik Saad: 32°34'N46°17'E.

Table 1. List of wild mammals recorded in Iraq.

Order	Family	Genus	Species	
Erinaceomorpha	Erinaceidae	<i>Erinaceus</i>	<i>Erinaceus concolor</i>	3
		<i>Hemiechinus</i>	<i>Hemiechinus auritus</i>	
		<i>Paraechinus</i>	<i>Paraechinus aethiopicus</i>	
Soricomorpha	Soricidae	<i>Suncus</i>	<i>Suncus murinus</i>	3
			<i>Suncus etruscus</i>	
		<i>Crociodura</i>	<i>Crociodura suaveolens</i>	
Chiroptera	Rhinopomatidae	<i>Rhinopoma</i>	<i>Rhinopoma hardwickii</i> <i>Rhinopoma microphyllum</i>	20
	Emballonuridae	<i>Taphozous</i>	<i>Taphozous nudiventris</i>	
	Rhinolophidae	<i>Rhinolophus</i>	<i>Rhinolophus ferrumequinum</i>	
			<i>Rhinolophus hipposideros</i>	
			<i>Rhinolophus euryale</i>	
			<i>Rhinolophus mehelyi</i>	
	Hipposideridae	<i>Asellia</i>	<i>Asellia tridens</i>	
	Molossidae	<i>Tadarida</i>	<i>Tadarida teniotis</i>	
	Vespertilionidae	<i>Myotis</i>	<i>Myotis blythii</i>	
			<i>Myotis capaccinii</i>	
			<i>Myotis emarginatus</i>	
			<i>Myotis nattereri</i>	
		<i>Eptesicus</i>	<i>Eptesicus anatolicus</i>	
			<i>Eptesicus bottae</i>	
			<i>Rhyneptesicus</i>	
			<i>Pipistrellus</i>	
Carnivora	Miniopoteridae	<i>Miniopterus</i>	<i>Miniopterus pallidus</i>	23
	Canidae	<i>Canis</i>	<i>Canis aureus</i>	
			<i>Canis lupus</i>	
			<i>Vulpes vulpes</i>	
			<i>Vulpes rueppellii</i>	
			<i>Vulpes zerda</i>	
	Ursidae	<i>Ursus</i>	<i>Ursus arctos</i>	
	Mustelidae	<i>Martes</i>	<i>Martes foina</i>	
			<i>Vormela peregusna</i>	
			<i>Mustela nivalis</i>	
			<i>Meles canescens</i>	
			<i>Mellivora capensis</i>	
		<i>Lutra</i>	<i>Lutra lutra</i>	

Order	Family	Genus	Species			
Artiodactyla	Herpestidae	<i>Lutrogale</i>	<i>Lutrogale perspicillata</i>			
		<i>Herpestes</i>	<i>Herpestes javanicus</i> <i>Herpestes edwardsi</i>			
	Hyaenidae	<i>Hyaena</i>	<i>Hyaena hyaena</i>			
	Felidae	<i>Felis</i>	<i>Felis silvestris</i> <i>Felis chaus</i> <i>Felis margarita</i> <i>Caracal caracal</i> <i>Lynx lynx</i> <i>Panthera pardus</i> <i>Acinonyx jubatus</i>			
		Bovidae	<i>Capra</i>	<i>Capra aegagrus</i>		
			<i>Ovis</i>	<i>Ovis orientalis</i>		
			<i>Oryx</i>	<i>Oryx leucoryx</i>		
			<i>Gazella</i>	<i>Gazella sandiyya</i> <i>Gazella subgutturosa</i>		
	Cervidae	<i>Dama</i>	<i>Damadama</i>			
		<i>Capreolus</i>	<i>Capreolus capreolus</i>			
	Suidae	<i>Sus</i>	<i>Sus scrofa</i>	8		
	Lagomorpha	Leporidae	<i>Lepus</i>	<i>Lepus capensis</i>		
<i>Lepus (Eulagos)</i>			<i>Lepus (Eulagos) europaeus</i>	2		
Rodentia	Sciuridae	<i>Sciurus (Tenes)</i>	<i>Sciurus (Tenes) anomalus</i>			
	Hystriidae	<i>Hystrix</i>	<i>Hystrix indica</i>			
	Dipodidae	<i>Allactaga</i>	<i>Allactaga euphratica</i>			
		<i>Jaculus</i>	<i>Jaculus jaculus</i>			
	Gliridae	<i>Eliomys</i>	<i>Eliomys melanurus</i>			
		<i>Dryomys</i>	<i>Dryomys nitidula</i>			
	Spalacidae	<i>Nannospalax</i>	<i>Nannospalax ehrenbergi</i>			
	Muridae	<i>Apodemus</i>	<i>Apodemus mystacinus</i> <i>Apodemus flavicollis</i> <i>Apodemus witherbyi</i> <i>Rattus rattus</i> <i>Rattus norvegicus</i> <i>Mus musculus</i> <i>Nesokia indica</i> <i>Nesokia bunnii</i>			
		Cricetidae	<i>Cricetulus</i>	<i>Cricetulus migratorius</i>		
			<i>Gerbillus</i>	<i>Gerbillus nanus</i> <i>Gerbillus dasyurus</i> <i>Gerbillus mesopotamiae</i> <i>Gerbillus cheesmani</i> <i>Tatera indica</i> <i>Meriones persicus</i> <i>Meriones tristrami</i> <i>Meriones libycus</i> <i>Meriones crassus</i> <i>Ellobius lutescens</i> <i>Arvicola amphibius</i> <i>Microtus socialis</i>	28	
			<i>Tatera</i>			
			<i>Meriones</i>			
	<i>Ellobius</i>					
	<i>Arvicola</i>					
	<i>Microtus</i>					
Cetacea	Delphinidae	<i>Sousa</i>	<i>Sousa chinensis</i>			
		<i>Tursiops</i>	<i>Tursiops aduncus</i>			
		<i>Neophocaena</i>	<i>Neophocaena phocaenoides</i>			
	Balaenopteridae	<i>Balaenoptera</i>	<i>Balaenoptera musculus</i> <i>Balaenoptera edeni</i> <i>Megaptera novaeangliae</i>			
		<i>Megaptera</i>				
Total	8	28	65	93		

Table 2. List of mammal species in Iraq evaluated by the IUCN.

IUCN Criteria ver. 3.1 (2014)	
Extinct (1)	
Saudi Gazelle <i>Gazella saudiya</i>	
Critically Endangered (1)	
Asiatic Cheetah <i>Acinonyx jubatus venaticus</i>	D
Endangered (4)	
Persian Leopard <i>Panthera pardus saxicolor</i>	C2a(i)
Mesopotamian Fallow Deer <i>Dama dama mesopotamica</i>	D
Long-tailed Nesokia <i>Nesokia bunnii</i>	A2e
Blue Whale <i>Balaenoptera musculus</i>	A1abd
Vulnerable (8)	
Mehely's Horseshoe Bat <i>Rhinolophus mehelyi</i>	A4e
Marbled Polecat <i>Vormela peregusna</i>	A2e
Smooth-eared Otter <i>Lutrogale perspicillata</i>	A2acd
Wild Goat <i>Capra aegagrus</i>	A2ed
Mouflon <i>Ovis orientalis</i>	A2ede
Arabian Oryx <i>Oryx leucoryx</i>	D1
Goitred Gazelle <i>Gazella subgutturosa</i>	A2ad ; marica C2a(i)
Finless Porpoise <i>Neophocaena phocaenoides</i>	A2ede
Near Threatened (7)	
Mediterranean Horseshoe Bat <i>Rhinolophus euryale</i>	
Pallid Long-fingered Bat <i>Miniopterus pallidus</i>	
European Otter <i>Lutra lutra</i>	
Striped Hyena <i>Hyaena hyaena</i>	
Sand Cat <i>Felis margarita</i>	
Euphrates Jerboa <i>Allactaga (Paralactaga) euphratica</i>	
Indo-Pacific Humpbacked Dolphin <i>Sousa chinensis</i>	
Data Deficient (3)	
Middle East Blind Mole Rat <i>Nannospalax elrenbergi</i>	
Indo-Pacific Bottlenose Dolphin <i>Tursiops aduncus</i>	
Bryde's Whale <i>Balaenoptera edeni</i>	

Bonn zoological Bulletin (BzB)

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The **Bonn zoological Bulletin** (BzB), formerly “Bonner zoologische Beiträge”, is an international, peer-reviewed, open access journal publishing original research articles, reviews, and scientific notes dealing with organismal zoology. Focus of the BzB are (1) taxonomy, (2) systematics and evolution, and (3) biodiversity and biogeography, all with respect to terrestrial animals. Terrestrial animals as understood here include those inhabiting fresh or brackish waters. Contributions from related fields like ecology, morphology, anatomy, physiology or behaviour are welcome when of clear relevance to the focus topics.

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Parenti RP (2008) A phylogenetic analysis and taxonomic revision of ricefishes, *Oryzias* and relatives (Belontiiformes, Adrianichthyidae). Zoological Journal of the Linnean Society 154: 494–610

Sullivan J (1994) *Bufo boreas*. In: Fire Effects Information System (U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory). Online at <http://www.fs.fed.us/database/feis/animals/amphibian/bubo/all.html> last accessed on December 28, 2009

Sztencel-Jablonka A, Jones G, Bogdanowicz W (2009) Skull morphology of two cryptic bat species: *Pipistrellus pipistrellus* and *P. pygmaeus* – a 3D geometric morphometrics approach with landmark reconstruction. Acta Chiropterologica 11: 113–126

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Cover illustration:

Rüppell's Fox *Vulpes rueppellii* from Iraq (Photo: Omar F. Al-Sheikhly) (this volume, pp. xxx-xxx).



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